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Prepared by
GNOSTIC CONCEPTS, INC.
for
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JET PROPULSION LABORATORY

Contract No. 954899, Basic

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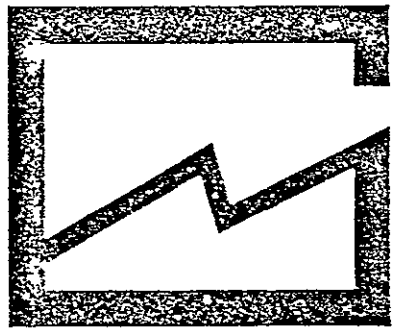

Gnostic
Concepts,
Inc.

The JPL Low-cost Silicon Solar Array Project is sponsored by the U.S. Department of Energy and forms part of the Solar Photovoltaic Conversion Program to initiate a major effort toward the development of low-cost solar arrays. This work was performed for the Jet Propulsion Laboratory, California Institute of Technology by agreement between NASA and DOE.

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ABSTRACT

This is the final report under Phase I of a program conducted by Gnostic Concepts, Inc., in accordance with Jet Propulsion Laboratory Contract No. 954899, Basic, a subcontract under NASA Contract NAS7-100, Task Order No. RD-152. Management responsibility for this program is within the Low-Cost Silicon Solar Array Project, in behalf of the US Department of Energy (DOE/ET) Solar Photovoltaic Program. The study was commissioned by the LSSA Project Analysis and Integration Manager, Dr. William T. Callaghan, with Task Force monitoring responsibility under the direction of Dr. James W. Doane and Dr. Jeffrey L. Smith.

The program described in this final report is an element of the JPL analysis of the industrialization process for the photovoltaic venture. As a part of this program, information concerning the investment process within US industry was collected. Emphasis was placed upon characterizing the critical elements in major high-risk investment decisions by industry. The relationship between these critical elements was interpreted as to how they influence the investment decision outcome.

The results of this analysis found wide differences between companies in the manner in which evaluation criteria are applied. Even within similar industrial sectors, totally different behavior patterns were observed. Motivation was determined to be the greatest single force to induce a company to invest in a high-risk venture. The higher the motivation, both financial and personal, the greater the risk a company is prepared to accept in a new investment. The effect of government actions upon these motivations and the degree of risk acceptance by industry is discussed on a qualitative as well as a quantitative basis.

The relative impact of alternative government programs and policies upon industry motivations, with its resulting impact upon photovoltaic industrialization, is assessed. This assessment is based upon field interviews with a cross-section of industry decision-makers to solicit their attitudes toward alternative government programs and policies. The government alternatives have been ranked on the basis of their ease of implementation and their probable impact. A commentary is included on the recommended sequence in which these government policies should be applied to maximize the industrialization of the photovoltaic venture.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. Executive Summary

1.1 INTRODUCTION

The basic objective of this report is to rank order government actions that will have a positive influence upon the investment decision processes in American industrial firms. The driving force for this study was the perceived need on the part of the government to accelerate the industrialization of the photovoltaic venture. To better accomplish this, a detailed understanding is needed of the decision process used by industrial concerns to select investment ventures.

It was found that a high degree of judgment, intuitive insight, courage, and conviction pervade the decision process in high-risk investments such as the photovoltaic venture. The investment decision process is further complicated in that it is continually changing as a result of variations in the national economy, industry fluctuations, performance of present investments, management style and philosophy, competition, technology advancements, and government actions or inactions. Such an environment does not easily lend itself to mathematical modeling or quantitative analysis techniques. It is not possible to characterize, catalog, or classify companies into predictable entities. All companies are managed by personnel subject to many demanding issues and possibly conflicting requirements. In arriving at an investment decision, all of these demands must be addressed and prioritized.

The general conclusions reached within this report are based upon a sampling of many companies. These companies varied significantly in their relationship to the photovoltaic venture and thus represented a wide spectrum of perspectives. The stated conclusions are as specific as possible, but caution should be taken if attempting to apply them to a specific company. They should be applied in a general sense with the expectation that a variety of companies, perhaps some not previously considered as likely candidates, will be attracted to the photovoltaic venture.

1.2 CONCLUSIONS

INFLUENCE OF GOVERNMENT ACTIONS ON BARRIERS AND RISK

MATRIX OF BARRIERS AND INCENTIVES

A matrix of the perceived barriers to investments and possible government incentives or actions is shown in Table 1.1. In each cell of the matrix is an indication as to the expected effect of a given government incentive on a perceived barrier. The degree of the effect of the government incentive on decreasing or increasing the barrier to investment is depicted with the following notation:

I^+	Significantly increases barrier
I	Increases barrier
0	No effect
D	Decreases barrier
D^-	Significantly decreases
*	Limited duration or under certain specific assumptions

TABLE 1.1
EFFECT OF GOVERNMENT INCENTIVES ON PERCEIVED INVESTMENT BARRIERS

	Government Incentives										
	Programs (Identifiable, Direct Support)								Policies (Indirect Support)		
Perceived Barriers to Photovoltaic Investment	Subsidize R&D	Subsidize Prices	Guarantee Market	Demonstrations & Experiments	Market Studies	GFE	Managment Fee	Production Demonstration	End-User Financial Assistance	Supplier Tax Preference	Loan Guarantee
Absolute											
Low financial reward	D^-	0	0	D*	0	D	D	D*	D*	D^-	0
Not in desired products/markets	0	0	0	0	0	0	0	0	0	0	0
Secondary											
High Risk--Market Proper identification	0	0	0	D	D^-	0	0	0	0	0	0
Penetration	D*	D	0	D	D	0	0	0	D^-	D*	0
High Risk--Technological Basic knowledge	D^-	0	0	D	0	I*	I*	D*	0	0	0
Obsolescence of proposed investment	I	D	0	0	0	D*	D*	D	0	0	0
System requirements	0	0	0	D^-	0	0	0	0	0	0	0
Attitude toward government presence	I	I	I	0	0	I^+	I^+	I^+	D^-	D	0
Competitive environment	D	D	D	D	D	D*	D*	D	0	0	0
Institutional issues	0	0	0	D^-	0	0	0	0	0	0	0
Balance of system costs	0	0	0	D	0	0	0	0	0	0	0

Notation of effect:

I^+--Significantly increases barrier
I-- Increases barrier
0-- No effect
D-- Decreases barrier
D^---Significantly decreases barrier
*-- Only under certain assumptions

The notations within the table are from the perspective of a potential investor in photovoltaics. This is to be distinguished from an investor who has already made the commitment to the photovoltaic venture. Only in a few instances will this distinction make any significant difference.

The government incentives have been divided into two major areas: programs and policies. The distinction is that programs are associated with fundings that are identifiable and represent direct support of the photovoltaic industry. Policies represent an indirect support of the photovoltaic venture. It may not be possible to identify specifically those dollars involved with supporting policies. Tax credits, for instance, may be difficult to identify directly with the photovoltaic venture, but they do represent government funding, in that at least in some future date, there will be a reduction in collected tax revenues.

RECOMMENDATION ON GOVERNMENT INCENTIVES AND ACTIONS

Based upon the influences that various government incentives have upon the overall spectrum of investment barriers and perceived risks, the ranking or classifying of government incentives into recommended and not recommended use is shown in Table 1.2. In addition, two incentive options have been listed as having possible use under special conditions. The recommended government incentives are:

- Subsidize research and development activities
- Establish supplier tax preferences
- Market studies
- Field experiments and demonstrations
- Establish end-user financial assistance

The two possible government incentives that could be implemented under certain conditions are production demonstrations and loan guarantees.

Those government incentives that are not recommended for implementation in the photovoltaic venture are:

- Subsidize prices
- Market guarantees
- GFE
- Management fee

TABLE 1.2
RECOMMENDATIONS ON GOVERNMENT INCENTIVES

Government Action	Commentary
Recommended	
Subsidize R&D	Most effective cost reduction program
Supplier tax preference	Reduce low financial reward barrier
Market studies	Direct at basic driving forces of markets, expand to detailed international scope, cover institutional issues
Field experiments/demonstrations	Redirect emphases to experimental aspects, direct at future markets on timely basis
End-user financial assistance	Stimulate market demand, begin with large incentive but decrease as prices decline
Possible	
Production demonstrations	Directed at only common materials or items for all suppliers; tends to exclude outsiders, biases market in favor of insiders
Loan guarantees	Appears to have no real influence; may assist new company formation or special temporary company conditions; best applied to users if needed to stimulate market
Not Recommended	
Subsidize prices	Overrules incentive to reduce costs, prolongs inefficiencies, slows technology advancement.
Market guarantee	Keeps prices up; inefficient use of tax dollars, similar influence to price subsidies
GFE	Biases market, does not stimulate market or advance R&D, freezes production technology, reduces implementation
Management fee	Same as GFE

In general, recommended government incentives accomplish the following objectives:

- Provide the most effective means to accomplishing step functions in the reduction of operating and manufacturing costs in the production of photovoltaic products (subsidize R&D)
- Provide a basis for reducing the investment required on the part of a company with minimal interference with internal affairs (supplier tax preferences)

- Provide information concerning the characteristics of the markets to be served and demonstrate to both the supplier and the user that photovoltaics can be effective in given markets (market studies, field experiments/demonstrations)

- Provide incentives for the end-user in a financial aspect that causes the increase in market demand without controlling or dominating the normal market relationships and driving forces (end-user financial assistance)

For those incentives that are listed as not recommended for the photovoltaic venture, the primary reasons for not using them are:

- They tend to override the natural market forces and their normal relationship to each other

- They tend to significantly interfere with internal affairs and the controlling of a company's own destiny

- They have a tendency of freezing or retarding the development pace of manufacturing and basic technology

There are those government incentives that under special conditions could offer momentary or localized positive influences upon the industrialization process. Before application of these incentives, however, significant study should be applied to their needs and their effect upon the overall long-range objectives of the industrialization process. If they can be implemented without interfering or distorting developments within a company or overruling normal market conditions, then they could very possibly be applied in specific areas.

APPLICATION SEQUENCE OF INCENTIVES IMPORTANT In the area of the recommended government incentives, it is important to note that the sequence in which incentives are applied can accelerate or hinder the industrialization process. For instance, it is important that technology be developed first, upon which field experiments and later demonstrations can be based. It would be unwise to label a field experiment as a demonstration when the technology had not been fully resolved. A failure in this case would act as a retardant force upon the market area to which it was exposed, and possibly discourage companies from entering the photovoltaic venture.

It would also be wiser to provide the supplier with tax preferences early in the development stage rather than to the end-user. An overstimulation of the market conditions could cause prices to remain at a higher than otherwise expected level.

The implementation of an end-user tax preference too early may be insufficient to account for the difference in selling price and the price needed to induce the end-user to purchase a photovoltaic-powered product. Thus the tax preference would have little relevance to the mass public. Only the very wealthy would be able to take advantage of the tax preference. Thus it could be concluded by the general public that government was once again favoring those who have great financial resources and discriminating against the lesser wealthy individuals within the population.

End-user tax preferences must be in relationship to the difference between selling price and the price the end-user would normally pay for some other source of energy. If that delta difference is extremely large, this would be an extremely inefficient use of tax funds. Those funds could better be directed at subsidizing the research and development activity and providing a basis for reducing costs on the supplier side.

A well-coordinated program is thus needed before government incentives are to be applied. Timing is important in the overall effect of the government incentives. The fundamental basis for the photovoltaic venture is the technology. Second is the supply of cost-effective products, and third the stimulation and development of the market to consume the output from production facilities.

L E A D I N G I N D I C A T O R S

SUMMARY STATEMENTS

MEASURABLE LEADING INDICATORS GIVE INSIGHTS The intent is to identify those leading indicators that would give constructive feedback on a timely basis to indicate if applied incentives have actually accelerated or in any fashion influenced the industrialization process. It would be desirable to know what the immediate effect of an incentive is on the development of the markets and the investments being made by companies in the photovoltaic venture. By having such timely leading indicators, it would then be possible to withdraw or at least modify incentives that are either not effective or creating negative influences upon the industrialization process.

DIFFICULT OR IMPOSSIBLE TO KNOW EXACT COMPANY POSITIONS The decision on the part of a prospective company to enter the photovoltaic venture or to significantly expand its participation in the venture will in general be kept secret until the last moment. In fact, additional investments by companies that are already in the photovoltaic venture may not even be noticeable outside the company for many months after the investment has been made. It will, of

course, be obvious at the time of the announcement of a product that a new company has decided to enter the photovoltaic venture. However, the decision to make the investment would have occurred many months in advance of the product announcement.

The conclusion is that it will be very difficult if possible at all to know the exact position of any company, either presently in or contemplating entrance into the photovoltaic venture. Leading indicators in their true sense will be virtually impossible to identify. They will be only relative in their nature and may not be leading at all. Identifiable indicators will consequently have a significant degree of delay built into them simply because of the secretive environment that will tend to surround a potential investment decision. This is a natural occurrence within the highly competitive industrial environment prevalent within the US. It should not be looked upon negatively or with great disappointment, but instead viewed with the perspective that companies have a legitimate need to protect their proprietary and confidential position until it is determined in the best interest of the company to announce their decisions and intended actions.

SELECTED INDICATORS

Identifiable leading indicators that are discussed in the report include:

- Tax report data
- Technology automation trends
- Attendance at public meetings
- Use of government data for company planning
- "Champion" feedback
- Industry organization data
- Product standardization trends
- Government position
- Financial analysis baseline

Of the above indicators, the first five offer some significant input as to the developments and commitment on the part of companies to the photovoltaic industrialization process. The last four, while offering some insights, offer no timely feedback and thus have reduced value.

TAX REPORT DATA REQUIRES CHANGE IN TAX FORM Once an incentive has been established, a method by which to obtain information concerning company investments would be through the use of the income tax reporting forms filed annually. If advantage of an incentive is to be taken by a company, then it could be required that a reporting of all investments in some detail must be reported through the income tax form. This would require a change in the present tax form but nothing substantial.

Certain tax credits or fast write-off of equipment expenditures and other R&D costs could act as an incentive to a supplier. The requirement could be added that if the stimulus is to be applied against the earnings of the company, then the company must report certain pertinent information within their tax form. Such information could include estimated number of man-hours devoted to photovoltaics, a listing of specific equipment designated for the photovoltaic venture, capital costs involved, or any other information that was deemed applicable to indicating the commitment of a company to the photovoltaic venture.

The end-user tax form could also be changed to request information concerning price and volume of photovoltaic products purchased during the year. This assumes that an incentive has been established that would induce an end-user to purchase photovoltaic products. Thus to take advantage of the incentive through tax credits or direct rebates, for example, it would require reporting all of the pertinent information on the income tax form for either a private individual or a company that may be using the photovoltaic product.

TECHNOLOGY AUTOMATION TRENDS A significant indicator of the commitment to the photovoltaic venture is the degree to which technologies are automated. Automation implies that a company envisions conditions to have stabilized for at least a certain period. It also indicates that the company has decided which avenues it will pursue in the production of photovoltaic products.

Knowledge of the automation may not be readily available, especially prior to the actual implementation of some of the automation equipment. It is unlikely that the intent to automate will be widely disseminated. The use of the previously mentioned tax report form would indicate the extent to which automation equipment is being implemented within the photovoltaic industry. Other sources of information concerning automation would have to be from within the companies. It may be difficult or impossible to establish such sources of information.

ATTENDANCE AT PUBLIC MEETINGS Associated with the photovoltaic venture are many public meetings in which attendees register their name, position, and company in which they work. This information could become valuable leading indicator material if properly analyzed. The type of information that could be obtained from the attendees list at public meetings in the photovoltaic venture would include:

- Name of the companies sending representatives
- Frequency of their attendance
- Type of meeting to which companies send representatives
- Number of representatives sent
- Level or job position within a company that each of the attendess represents

This information is already within the public domain and would require no new forms or data collection mechanisms. While this type of indicator would not provide information concerning the quantitative degree to which a company has committed to the photovoltaic venture, it would supply information concerning who the potential new companies could be in the near term.

USE OF GOVERNMENT DATA FOR COMPANY PLANNING The government provides a tremendous amount of information concerning the photovoltaic venture, and in particular concerning potential markets and the requirements therein. The identification of photovoltaic markets and their basic driving forces is key to any investment attempts a company may develop. The key indicator would be, does industry use the published government data for preparing their strategic plans and marketing approaches? To verify the use of such government marketing material would require a surveying of at least selected companies, both within and outside of the photovoltaic venture.

"CHAMPION" FEEDBACK One of the principal elements that must be present in the investment environment is the "champion" of the proposed investment. This individual will probably be the most informed as to where the proposed investment stands within the company's investment environment. The identification and continual communication with the "champions" at each prospective company could become a type of leading indicator. Through the communication links associated with these "champions," it would be possible to obtain feedback information that could be used to modify existing government incentives or those incentives that are under consideration. A "testing" of the government incentives under consideration could be obtained through the reaction of the "champions" at each of the identified companies.

CONCLUDING STATEMENT ON LEADING INDICATORS

Decisions in industry for high-risk ventures are based on judgment, courage, and insight in the final analysis, none of which are truly measurable in quantitative values. As a consequence, virtually no analytical perspective can be attached to leading indicators. Most cannot truly classify as leading indicators because of the lack of timely insights. The quantitative measurement of these indicators is also difficult to support. Without a reliable and measurable set of leading indicators, the only approach that can be taken in applying government incentives is to direct such incentives toward the fundamentals of the investment environment rather than the special conditions that may exist at selected companies. Through applying fundamentally sound incentives directed at basic barriers and risks a far greater attraction of the best-qualified companies for the industrialization process will occur.

1.3 SUMMARY OF INVESTMENT DECISION ENVIRONMENT

DIMENSIONS OF UNCERTAINTY

OVERVIEW

There are many elements involved in describing a given company's business position or business status. Such elements would include gross revenues on an annual basis, share of market, number of employees, number of facilities, square footage of facilities, profit margins, and many other such items. While these elements do describe in great detail the present status of a company, they add little if any insight into what is involved in arriving at an investment decision concerning a significant shift in their business position. Neither do those items place any perspective upon the risk associated with that shift.

THREE APPLICABLE ASPECTS TO BUSINESS POSITION There are, however, identifiable elements that describe a company's business position in such a fashion that the significance of a shift can be evaluated. Such a description would relate to the characteristics and elements to be considered in connection with a venture investment. One such description that involves the principal aspects of a company's business position and has relevance to an investment in a new venture is portrayed in Figure 1.1.

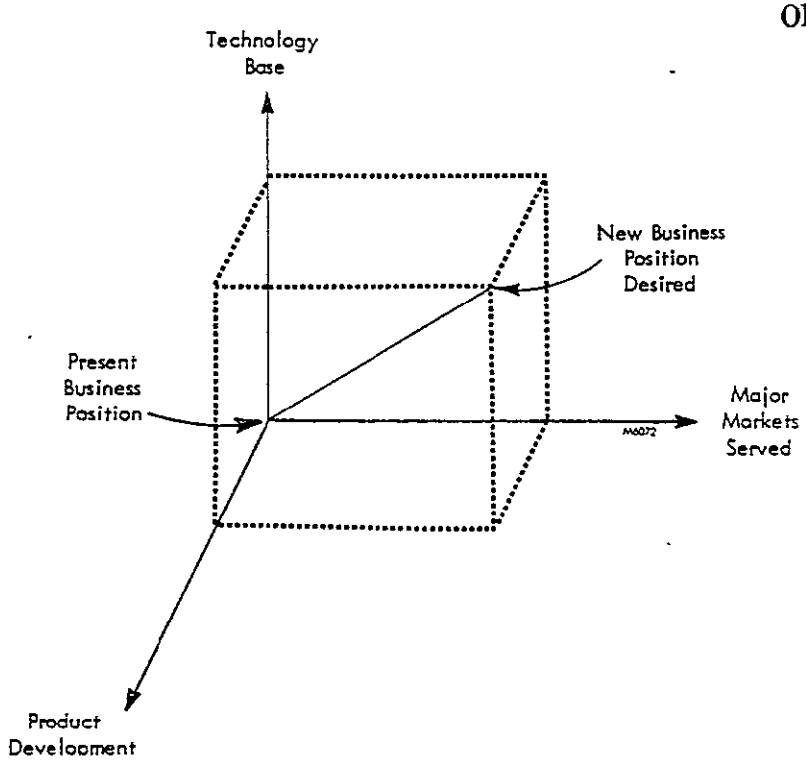
The origin of the three-dimensional figure represents the present-day business position of a company in regard to:

- Major markets served
- Product available
- Technology base

Any new business investment involves decisions concerning changes in these three major aspects of the company's present status. The degree of change in each element will vary, depending on the nature and size of the proposed investment. In general, any company entering the photovoltaic industry will be changing its business position, since in most cases no previous activity would have existed in the photovoltaic area. Consequently, this requires involvement in new markets using new products built with new technologies that were probably not employed by the company prior to entering the photovoltaic industry.

FIGURE 1.1

CHANGE IN BUSINESS POSITION



ESTABLISHED FIRMS FACE SIGNIFICANT CHANGES ALSO

For companies in the photovoltaic industry, the expected changes in the photovoltaic industry will cause a change in their present business position. This will involve investments in product development, the establishment of new technologies, and in many cases include moving into new markets.

RISK ASSOCIATED WITH CHANGE A change in a company's business position includes the decision to invest, the actual capitalization of that investment, and an evaluation of risks. For any type of change in company position, there are always risks. These are the elements of the investment that cannot necessarily be quantitatively or analytically described. Judgment, courage, and determination on the part of the investing company are often required to arrive at a decision.

MAJOR MARKETS SERVED

Not all major markets can be penetrated by photovoltaic products. Certain ones will, however, hold a much greater potential for penetration. To relate the concept of markets served to the photovoltaic venture, a selected set of markets in which photovoltaics will have reasonable penetration potentials is shown in Table 1.3, along with typical applications therein.

TABLE 1.3
POTENTIAL PHOTOVOLTAIC MARKETS
AND REPRESENTATIVE APPLICATION AREAS

Potential Markets	Representative Application Areas
Agriculture	Small water pumping Irrigation water pumping Distributive Deep well
Cathodic Protection	Gas and oil well heads Pipelines Transmission Distributive Bridges
Communications	Remote repeaters Diesel replacement TEG replacement Primary battery replacement New sites Navigational aids Telemetry
Consumer Electronics	Watches Calculators Recreational vehicles Battery chargers Backpacking
Electric Power	Central power generation Substations Distributed power generation
Government/Military	Portable field communications Water purification Remote installation power Test facilities Demonstration projects
Housing & Construction	Consumer facilities Single-family Vacation homes Commercial facilities Institutional facilities Industrial complexes
Rural Electrification	Lighting Water pumping Village industries Medical supply storage
Other	Electric vehicle Road signs Street lights

For the present and future suppliers of photovoltaics, these markets will in general be new and untested. Entering such markets will have associated with them tremendous risks in attempting to identify applications, customers, and methods of penetration. Additionally, there will be channels of distribution, methods of doing business, service requirements, payment schedules, and many other items that could conceivably be uniquely different from past practices for these photovoltaic supplier companies. Supplying to these new markets will not necessarily be an extension of older practices from other market areas with which the companies are familiar.

PRODUCT DEVELOPMENT

Products are those physical items which a company ships to a user through various distribution channels and in return receives some financial payment or reward. The customer which receives these products may or may not be the ultimate end-user. The products may be combined with other components or other products to form a more complex or a higher value added end-product that is then distributed to end-users.

The typical product supplied by photovoltaic companies will be flat-plate photovoltaic panels which are then combined with other components or products, such as batteries, structural material, power conditioning equipment, and electrical interconnection material, to provide a photovoltaic power supply. This in itself is a product, but even this product will ultimtely be combined with some other piece of equipment, such as a microwave relay tower or a water pump, to provide a functional product for some end-user.

BASIC ELEMENTS OF PRODUCTS Products have three basic elements:

- Design
- Packaging
- Manufacturing processes and techniques

A change in any of these three elements could constitute product development. Minor changes in any of these three aspects may simply be considered a correctional action on the part of the supplier to overcome some minor defect. However, significant changes in any of these three aspects would imply product development.

PRODUCTS THE EASIEST TO EVALUATE Generally speaking, products are the easiest of the three major aspects of a company's business to define quantitatively and to analyze accurately. Products can be described through specifications, material content, and performance characteristics. Variations in these specifications

can be directly related to financial investments and the required resources that must be brought together to formulate the change. Performance characteristics of products are generally the most difficult to guarantee early in the investment decision process. However, a significant amount of accumulated experience is usually available within the design and manufacturing staff to be able to effectively reduce the risks associated with meeting ultimate performance requirements.

TECHNOLOGY BASE

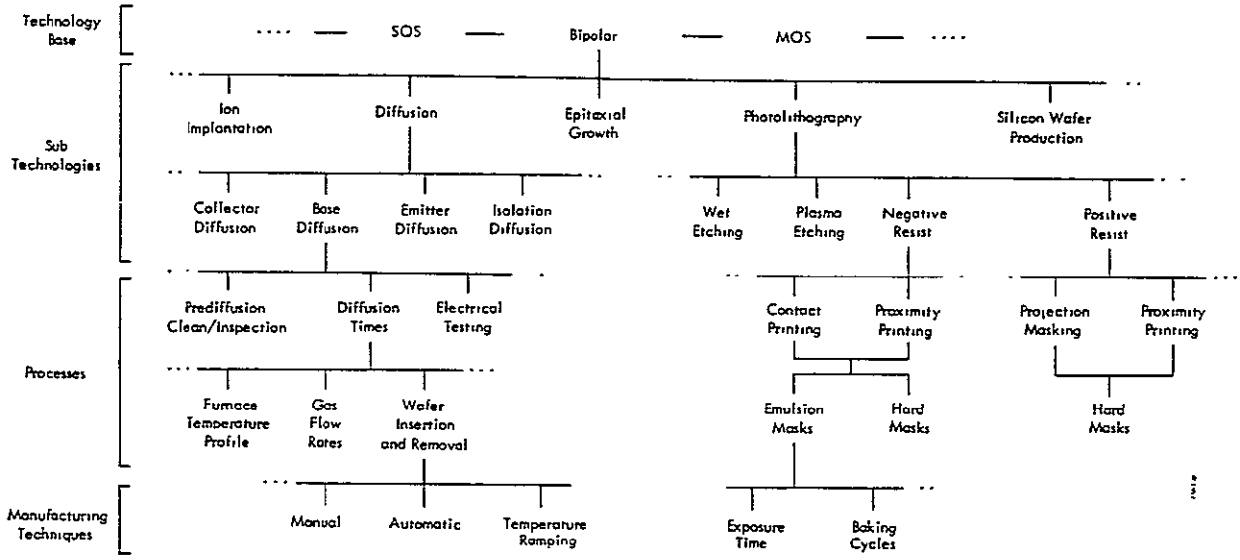
The technology base of a given company, in broad terms, is the collection of all of the subtechnologies, processes, and manufacturing techniques required to produce the company's products. In general, there are selected elements within this collection that give the technology base its predominant characteristics.

The semiconductor industry can be used to typify technology definitions and to distinguish between processes, manufacturing techniques, and subtechnologies. A limited sample of the technology bases, subtechnologies, processes, and manufacturing techniques used in the semiconductor industry are shown in Figure 1.2. This example is from the manufacturing area for the circuit devices or chips, as this area has the most relevance to the photovoltaic venture.

TECHNOLOGY BASE COMPOSED OF SUBTECHNOLOGIES, PROCESSES, AND MANUFACTURING TECHNIQUES The technology base is composed of a group of subtechnologies which have both major and minor elements. Each of the subtechnologies, in turn, is composed of a series of major and minor processes. The manufacturing techniques are those physical items that must be performed in accordance with the process specifications. The example used here is the bipolar technology base for the semiconductor industry. If, however, a different technology base were selected, then a different composition of subtechnologies, processes, and manufacturing techniques would have to be implemented. Many elements described in the bipolar process may be entirely suitable for use within this different technology base. However, the specific collection required for the bipolar technology base could not satisfy the requirements of the base technology for SOS (silicon-on-sapphire), or any other base technology.

FREQUENT CHANGE ONLY AT LOW END OF TECHNOLOGY HIERARCHY Within the hierarchy of the technology base, which includes the subtechnologies, processes, and manufacturing techniques, it is noted that the further down in the hierarchy one proceeds, the more flexibility and likelihood of evolutionary changes exist. For instance, manufacturing techniques will constantly be changed and implemented as new ideas are generated. However, it is very unlikely that a

FIGURE 1.2
DISTINCTION BETWEEN TECHNOLOGY BASE, SUBTECHNOLOGIES, PROCESSES, AND MANUFACTURING TECHNIQUES



company will ever change from one base technology to another unless survival is at stake. Additional base technologies could be added on occasion to broaden company capabilities. This would also allow for a transition or evolutionary changeover from one technology base to another if so desired, but the time period would be very long. No sudden shift will occur.

While manufacturing techniques may continually be in a state of flux, there is a certain solidarity and stability associated with the processes. Process changes occur more slowly than do changes in the manufacturing techniques.

Subtechnology changes are even more rare than process changes. Only long-range evolutionary changes will be noted in subtechnology changes.

Thus as one moves down through the hierarchy of the technology base, one finds increasing opportunities for evolutionary changes occurring; but at the same time, there is a decreasing level of investment required with these changes. Conversely, going up through the hierarchy of the technology base, one finds an increasing reluctance to change and larger capital investments required for such changes.

WILLINGNESS TO AUTOMATE BASED ON PERCEIVED STABILITY

The willingness to automate a new technology concept is dependent upon the perceived stability or maturity of the new technology within a given time frame. For instance, if the technology appears to be safe and secure for the next five years, automation may take place. However, if it is perceived that an even newer technology may replace the present new technology within two years, then automation will not take place unless influenced by government policies. Such a policy could be rapid depreciation, such that the investment could be recouped within the two-year period.

RELATIONSHIP OF DIMENSIONS OF UNCERTAINTY

The relationship between the three major aspects of a company's business position and the hierarchy of the photovoltaic venture is shown in Figure 1.3. At the base of the hierarchy are photovoltaic technology aspects involved in assembly of photovoltaic panels or concentrator units, along with technologies of solar cell devices and materials involved.

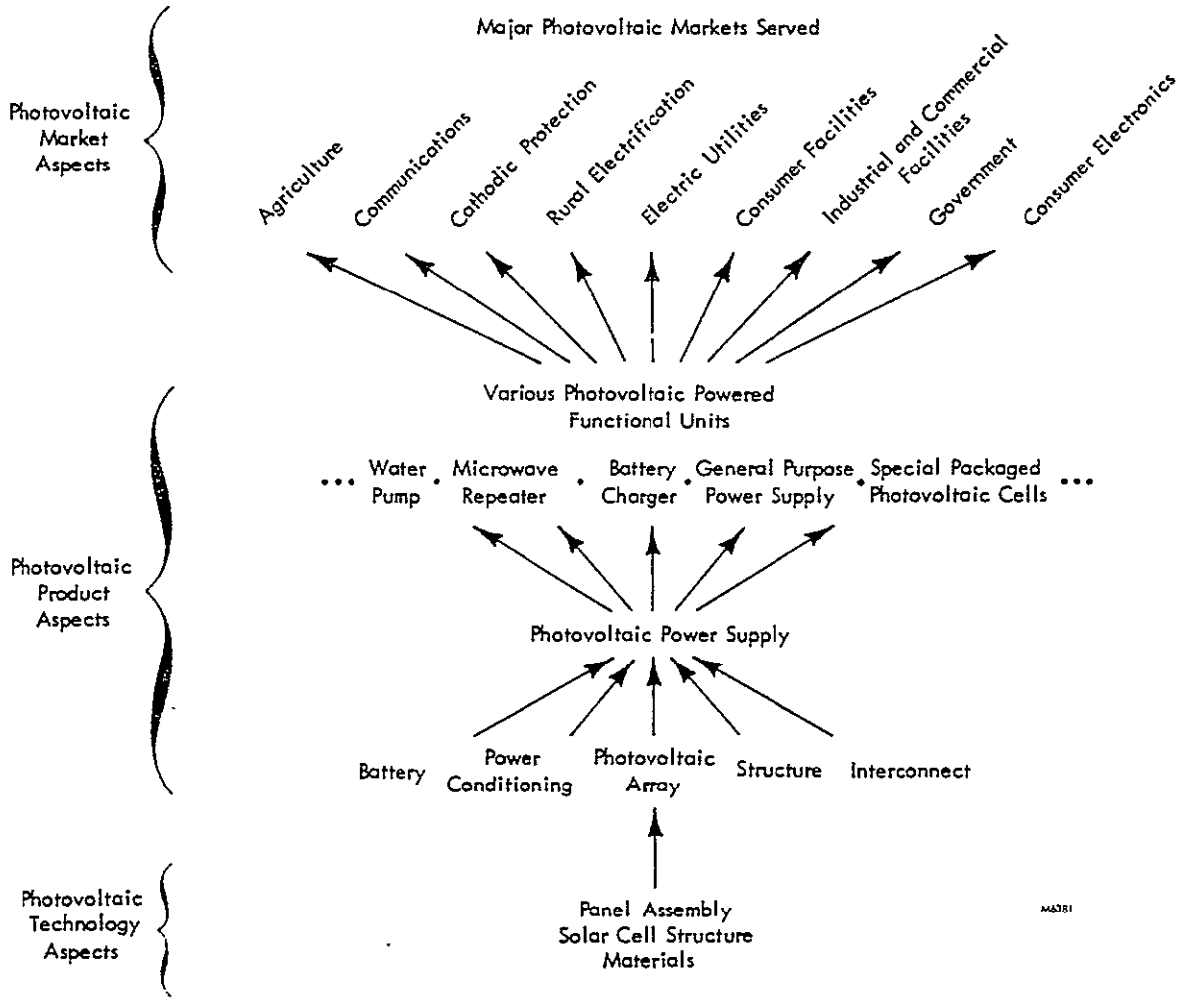
The photovoltaic product aspects began with the assembly of photovoltaic panels into photovoltaic arrays. The arrays are then coupled together with other components, including batteries, power conditioning, physical structures, and electrical interconnections, to form a solar power supply.

The solar power supply is then integrated into the design of a functional unit. Such functional units would include water pumps, microwave repeater sites, battery chargers, or special products such that the end result is a functioning unit that performs a useful service.

These photovoltaic products can then be applied to various applications within many market segments. A given product may be applied to several applications within one market segment, or may be used in applications throughout several major markets. In general, a photovoltaic product will have been designed for a specific application within a given market, but through only slight modifications may find suitable application within other major markets.

FIGURE 1.3

HIERARCHY OF MARKETS, APPLICATIONS, PRODUCTS AND TECHNOLOGY



C H A N G E I N B U S I N E S S P O S I T I O N

OVERVIEW

The investment in a new venture not only includes the bringing together of the various company resources, but also a selection of the route a company will follow in arriving at the new business position. There are an infinite number of routes available. They can be categorized through a description of the order or sequence in which the three major aspects of the new business position will be pursued. By grouping the routes in such a fashion, certain predominant characteristics can be noted. Each group of routes will have its own advantages and disadvantages and methods of handling risk. The particular route that a company may follow can be heavily influenced by government activities, competition, previously established company resources, and changing market conditions.

The basic routes by which a company can move to a new business position include:

- Direct route
- Series development route
- Combined development route

There is no reason to believe that a company must remain upon one of these particular routes once they have begun to move into an investment area. It may be that through the obtaining of additional data and information, an entirely different route will be selected midway through the venture to complete the final stages of the investment. Thus combinations of the above-mentioned routes could add tremendous variations to the available options, depending on a company's particular situation.

DIRECT ROUTE

The direct route involves the investment of resources into the development of all three aspects of the company's business position simultaneously. It implies that a company has concluded they have tremendous resources available and sufficient information in all three aspects to successfully accomplish the required tasks.

HIGH-RISK APPROACH This is the highest-risk route, especially if only company resources are being used. This requires investments to be made in technology, product, and market development simultaneously. Thus all of the risk associated with each of these aspects are compounded and require a tremendous coordination effort within the company to keep the total investment to a minimum.

Pursuit of this route often increases the overall investment because of the lack of timely feedback from market inquiries to influence product development. In addition, commitments within the marketplace may be made that cannot be supported as a result of a slower product or technology development than originally assumed.

ACQUISITIONS REDUCE RISK Pursuit of the direct route usually is associated with an acquisition or a series of acquisitions. Through the acquisition, many things can be accomplished simultaneously. The acquisition of a company already in the newly desired markets provides a foundation of customer contacts, knowledge concerning the customer's needs, and pricing information, including price elasticity data. Depending on the nature of the acquisition, a product or manufacturing technology base can also be acquired.

SERIES DEVELOPMENT ROUTE

In contrast to the direct route is the series development route, in which a new business position is obtained through a series of developments. Typically such a sequence would be the development of a technology base, then products, then the development of new markets. While other combinations of these three aspects could be devised, this is the most frequent approach if only company funds and internal development activities are to be used.

TECHNOLOGY SHOULD BE DEVELOPED FIRST The development of a technology after product development or market development simply restricts the rewards to be gained. If the technology development is required, then it should occur before product and market development efforts if maximum return on the investment is to be obtained. The technology is the foundation of the three-dimensional change of a company's business position.

REDUCES RISK OVER DIRECT ROUTE AND ADDS FLEXIBILITY The series development route reduces the risk considerably over the direct route. The drain on the company's resources at any given moment is also less severe. Additionally, it allows for significant positive feedback to influence the development route being pursued. The disadvantage of this route, however, is that it requires a tremendously long developmental time.

Another advantage of this approach is that the sequence can be stopped at any moment and other options pursued. It offers significant flexibility, especially in areas where a company is not extremely confident of the market details.

COMBINED DEVELOPMENT ROUTE

There also exists an infinite number of combinations of the direct and the series development routes that can in general be segregated into two categories:

- Parallel series development route
- Series parallel development route

There can even be combinations of the above two types of routes, as the approaches to a new business position are as varied as there are companies desiring to reach new business positions.

TECHNOLOGY DEVELOPMENT INVOLVED IN EARLY PART OF SEQUENCE

The most common approach used in the parallel series route is that of first developing the technology base and the appropriate products simultaneously and then introducing them into new markets. For the series parallel development route, the most common approach is to first develop a technology base, then pursue the development of products and new markets in a simultaneous fashion. This is typical of large corporations that have significant technology research and development facilities.

GOVERNMENT ACTIONS CAN INFLUENCE RATE OF DEVELOPMENT

Risks can be reduced in these approaches through a series of small acquisitions and/or government fundings. The parallel pursuit of two aspects of a desired new position can be handled by most companies. However, the development of all three aspects at once is very seldom pursued. Through government actions, if the risks or investment can be reduced in one or two of the three aspects, then a company may be able to accelerate its arrival at the new business position. Combining government actions and a series of small acquisitions can accelerate the arrival even faster.

C L A S S I F I C A T I O N O F C O M P A N I E S

NEED TO CLASSIFY

The approaches to developing a new business position are varied in nature, size, and the route pursued. To arrive at some common denominators such as perceived barriers to investments, basic elements of the investment process, and items influencing the final investment decision, there is a need to classify companies in a meaningful order.

One of the most common methods of classifying companies is to segregate them by their industry type. Examples of this would be petroleum-based, chemical-based, material, industrial, and semiconductor companies. Within each of these industry-type classifications, the companies can be subgrouped still further by their annual dollar volume of business and assets. Other schemes of classifying these industrial types would include segregating them by markets served or by the type of structure that the company represents; i.e., a narrow-based company serving relatively few markets, or structured in the form of a conglomerate in which there are many divisions and subsidiaries serving many market areas. Still other classification schemes could be based upon their technology or their type of products.

In all of these cases, very little insight is obtained as to what the investment processes are: namely, how a final decision is made concerning an investment, how risk is handled, or what the perceived barriers may be to an investment, especially in a high-risk area such as the photovoltaics venture. Thus there is a need for a classification scheme that brings to the forefront the motivations why a company would invest in a high-risk operation.

CLASSIFICATION BY MOTIVATION AND PHOTOVOLTAIC RELATIONSHIP

FOUR COMPANY GROUPINGS IN RELATION TO PHOTOVOLTAIC VENTURE

In addition to motivation as a means of classifying companies, an additional perspective is based upon their relationship to the photovoltaic venture; i.e., their relationship to the technologies involved, the products, and the markets to be served. Combining these two schemes gives greater insights into how a company may view the ramifications in the photovoltaic venture.

The concept of classifying companies as to their relationship to the photovoltaic venture and their motivation for making the investment is shown in Table 1.4. The photovoltaic industry can be looked upon as one that supplies electrical generating equipment. Thus the first classification of companies that would be identified would be those that are:

- Suppliers of energy-generating equipment
- Suppliers of materials that would allow for the generation of electrical energy
- Related peripheral equipment companies

These companies will be influenced by a significant photovoltaic industry development program. Their markets will especially be influenced in a direct fashion.

TABLE 1.4
COMPANY GROUPINGS BY INVESTMENT MOTIVATION

Company Groups	Investment Motivation	
	Major	Minor
Energy Market Companies		
Consumable producers	Protect market position through diversification in energy business	Enhance image
Energy-generating equipment manufacturers	Long-term ROI	Short/intermediate-term ROI
Related equipment manufacturers		
Large Energy Users		
Functional systems supplier	Protect/develop supply source	ROI
Related Technology Companies		
Semiconductor-based companies	Major business spin-off	Diversification
Materials-oriented firms	High growth, near-long-term ROI	Image
	Industry technology leader	
Unrelated Companies		
Conglomerates	High growth, good ROI	Image
	Diversification	Long-range position
	Enhance other markets	

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Another category of companies are those firms that are involved in the consumption of the electric energy that is generated. In particular, reference is being made here to large energy users who may require a captive source of electrical energy.

These two categories of companies thus cover the market and the product aspect of a photovoltaic business position.

A third category of companies that would be involved or interested in photovoltaic industry developments would be those that have a compatible or related technology base. This would not only include a technology in the solar cell device area, but also technologies in the generation and production of the basic raw materials that may be consumed in or part of photovoltaic products. This type of company covers the third aspect of the photovoltaic business position, namely the technology base.

A fourth type of company classification also exists. This would be the company that has no relationship at the present time to the photovoltaic industry or the energy-producing industry. There exist such companies that will be motivated to enter this particular potential high-growth industry as a result of an internal diversification objective.

MAJOR AND MINOR MOTIVATIONS The motivation for any of these types of companies to invest in the photovoltaic venture can be broken into major and minor groupings. An investment in the photovoltaic industry will always be driven by one or more major motivations. At the same time, there may be several minor motivations that would also encourage a company to make the investment. However, these by themselves would not be of sufficient magnitude to cause a company to make the necessary investments. These minor motivations serve to round out the total package for justifying the entrance into a high-risk photovoltaic venture.

SUMMARY OF MAJOR AND MINOR MOTIVATIONS In summary, the major motivations for a company to invest in a photovoltaic venture would include:

- Protect market position through diversification
- Long-term return on investment
- Major business spin-off
- High-growth opportunity
- Technology extension
- Enhance other markets
- Protect or provide assured sources of products

The minor motivations would include:

- Enhance company image
- Intermediate return on investment
- Long-range position

Any actions that the federal government may take in its photovoltaic program should thus be directed at causing an increase in the motivations for a company to make an investment. In addition, government actions should be so designed as to not eliminate any of the potential companies that may have any motivation for entering the photovoltaic industry.

SPECTRUM OF DECISION METHODS AND RELATED INFLUENCES

SOURCES OF INVESTMENT PROPOSALS

Before a company can arrive at a decision to invest in photovoltaics or any other venture, there must be a proposal set forth that suggests that an investment be made. Some source and mechanism for bringing this proposed investment to the attention of the corporate decision makers must exist within the company.

FOUR BASIC INVESTMENT PROPOSAL SOURCES There are four basic sources that can generate an investment proposal and carry it forward to the attention of the appropriate individuals.

The major sources for investment proposals include:

- The business unit
- A corporate executive
- The corporate research and development group
- Venture analysis group

Within a given company, any one or a combination of these investment proposal avenues may exist. In addition, there may be specialized methods by which investment proposals are also generated within those companies.

MECHANISTIC ASPECTS ONLY COMMONALITY BETWEEN COMPANIES It should be noted that any of these approaches within a given company will differ from its counterpart in some other company, even within the same industrial classification of companies or any other classification that may be applied. In effect, each company tailors the basic investment proposal procedures and builds into them those items that the company wishes to accentuate.

BUSINESS UNIT UP PROCESS The most common approach to development of a new business venture is from the grass roots level, especially in a major organization. The idea germinates within a division at a relatively low level and builds slowly, ultimately becoming a line item in the division's overall business plan. It does not become visible to the corporate executive level until it has reached a size that requires an investment above a predetermined level, depending upon how the product and the potential liability to the organization has been defined.

By this time, the investment has received the adamant support of at least one or more "champions." Such a "champion" will carry the bulk of the effort in seeing that all of the necessary requirements for a corporate review are met. In most cases, this individual is one who is known and creditable to the executive staff of the company.

The new proposed venture also generally will fit within a particular market interest of the supporting division and will have at least a long-term potential for excellent return on investment. In addition, the proposed idea will generally fit the accustomed manner of marketing and distribution of the other divisional products. There are exceptions to this, where the company has strong diversification tendencies and divisions are given wide latitudes. This is not, however, the general case.

CORPORATE EXECUTIVE DOWN PROCESS Occasionally the corporate executive level will strategize that the company should move into another investment area. The suggestion for an investment may come from a single individual within the corporate staff or from a group of individuals who feel such investments should at least be investigated.

Often the decision process in this case is not based upon nearly the large amount of quantitative data that would ordinarily be used should a division submit a new investment consideration to the executive staff. Upon receipt of a suggested investment area, the appropriate division will generate an implementation plan and resubmit it to the executive staff for approval. In many cases, approval of the basic concept has probably already been implied and it now becomes a matter of approving the tactical details. In effect, the "champion" is a decision maker at a corporate level and by his nature will not require as sophisticated a justification as he might otherwise require on an investment in which he is not as familiar or emotionally involved.

The investment proposal process within the supporting division is essentially the same as described in the business unit up process, except that less detail is usually needed and a quicker decision can be arrived at due to the prior interest on the part of the corporate staff. If, however, the corporate staff member who suggested the investment proposal originally is not a dominant member of the corporate decision group, the proposal may require the same depth of analysis as would otherwise be required.

CORPORATE R&D GROUP PROCESS Another source of investment proposals is the corporate research and development (R&D) group. A major function of many corporate R&D groups is to stay abreast of the technologies affecting their company's basic business, including developing technologies that may represent reasonably allied future diversification programs. In most cases, the R&D group in following and developing technologies attempts to transfer the technology to an operating divisional group at the earliest possible time. This is done because the divisions truly have greater resources for implementing the new technologies, particularly in the business and marketing area. Even in the cases where the technology is not directly related to a division's products, the R&D group will attempt

to place the technology in the most appropriate division. Once the technology base has been successfully transferred to a division, the investment proposal process follows the business unit up procedures.

VENTURE ANALYSIS GROUP PROCESS Within many companies there exists a specialized group known as the venture analysis group. The objective of this group is to investigate programs that might lean to the continued investment of company resources into high-growth opportunities. This group will pursue and analyze proposed concepts for investments from many sources. They would include sources within the group, from the R&D organizations, from the various business units, the corporate staff, and from sources outside the company also.

Where such organizations exist, all proposed invesments, regardless of source, will be funneled through this venture analysis group. This group will be especially equipped to supply all of the needed information for the executive staff at the time a decision must be made. The actual work in the preparation of the reports may ultimately have to be supplied by the supporting division or the R&D group, but it will be under the direction of this venture analysis group and special assistance will be made available.

The processes and procedures carried out by the venture analysis group do not differ in substance from those required of a business unit up proposal process. The advantage of a company having a venture analysis group is that more opportunities can be investigated, coordinated, and ranked.

EXISTENCE OF FINAL AUTHORITY

Once all of the necessary requirements of the investment proposal process are met, there still needs to be a final decision made by the corporate staff before an investment can be finalized. The involvement of the corporate executives responsible for the final investment decision adds a new element into the investment picture. The existence of this final authority is for the purpose of supporting or changing the nature of the investment or denying investments in high-risk ventures.

SIZE OF FINAL AUTHORITY GROUP VARIES The size of the final authority group can vary from one to many members. The size is generally unrelated to the size of the corporation. The exception to this case would be for the newly formed or very small corporations, where typically a one-member final authority will dominate such companies. However, for the medium-sized to large corporation, there appears to be little relationship to company resources, size, or any other physical and financial parameters.

There are several large corporations that are run by single-member final authorities. Likewise, there are large corporations that are directed by a multimember final authority group. The size of the group is more related to an evolutionary development process than any other identifiable characteristic. If the original founding group or at least a group of individuals that were extremely dominant during the early development of a corporation is still present, then the final authority group is composed of a small group of individuals. If, however, over the years there has been a change in top corporate executives and a growth in the corporation, the tendency for the formation of a larger final authority group is more evident.

DOMINANT MEMBERS IN ALL GROUP SIZES In those cases where the multimember group that forms the final authority has grown in excess of seven to eight people, there is the informal evolution of an inner subgroup. This subgroup tends to dominate the thinking and activities of the larger group. These are the more influential members of the corporate staff who have developed a strong political base within the corporate structure.

For those groups that range from the threeto seven-member size, there is always a single dominant personality within the group. The remaining members play a supportive role to this dominant figure.

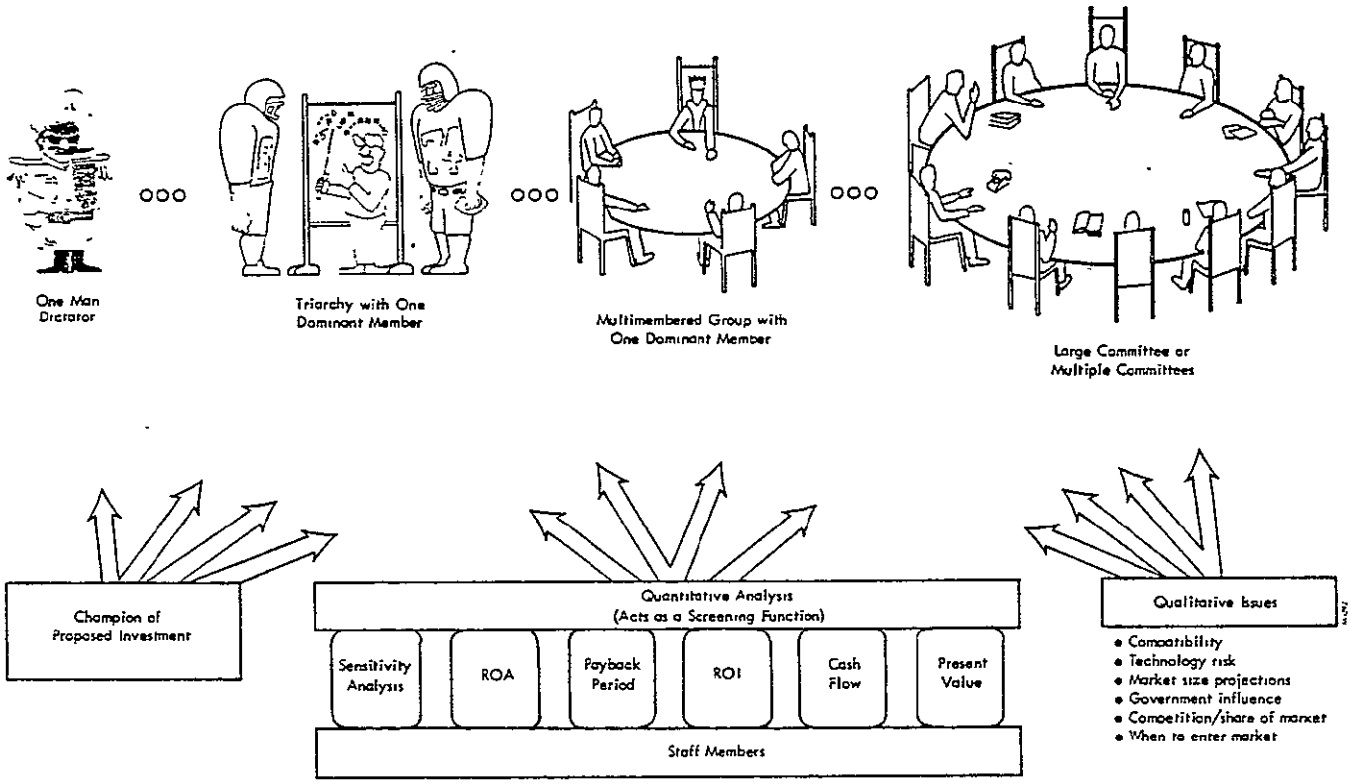
MAJOR COMPONENTS IN THE FINAL DECISION PROCESS

The final decision process is a critical element in the overall investment environment. The interaction of the final decision authority and the supporting "champion" of the proposed investment, along with the influences of the statistical and analytical parameters are portrayed in Figure 1.4.

The final authority group makes no decisions unless requested. There must be some outside influence forcing the group to make a decision concerning an investment. Even in the case where an investment suggestion or strategy is put forth by a member of the final decision-making group, it must be sent downstream within the corporation and resubmitted through normal channels with all of the supporting information.

MAIN ELEMENTS INTERACTING DURING FINAL DECISION PROCESS There are three main elements that come to play during the final decision process that will influence the decision of the group. These influences include:

FIGURE 1.4
SPECTRUM OF ULTIMATE DECISION-MAKERS AND INFLUENCES AT PLAY



- The "champion." Such a "champion" must exist regardless of the company size or structure and must usually be in addition to any "champion" that may exist within the ultimate decision-making group. The strength and stature of an active "champion" of the proposed investment is critical and will have a significant influence upon the final decision.

- The results of quantitative analysis. These analyses are based primarily upon financial parameters, such as the return on investment, return on assets, discounted cash flow analysis, present value of investments, payback period, and many other sensitivity analyses as may be determined by the ultimate decision-makers.

- The relative knowledge and opinion on qualitative issues by both the "champion" and the final authority group. Qualitative issues include such items as technology risk evaluations, market size projections, government influences, competition and share of market potential, proper timing to enter the market, and compatibility with corporate objectives.

INTERACTION OF COMPONENTS It is the quantitative analysis that provides the foundation for the initial discussions concerning the proposed investment. The qualitative issues can, however, become the dominant factor in the final decision process. It is the role of the "champion" to act as a catalyst and to be prepared on all of the qualitative and the analytical issues. He is the salesman of the proposed investment and in general must convince the final decision-makers of the validity, need, and ultimate reward to be gained from the proposed investment.

In general, the final decision-making group will be reluctant to make any investment and will be interested in only the best investment that can be made out of all of the potential opportunities. Especially for the mediumto larger-sized corporations, there are always significant numbers of investment opportunities being presented for consideration and each investment opportunity will be supported by some operating division and "champion." Thus each investment opportunity is in effect not only trying to meet minimum company standards, but is competing with all of the other investment opportunities that are being proposed.

PERCEIVED INVESTMENT BARRIERS AND GOVERNMENT INCENTIVES

PERCEIVED INVESTMENT BARRIERS

The insights to the motivations to invest, the elements of the investment proposal process and final decision environment, and company characteristics lead to the identification of investment barriers. There are no two companies in the US industrial complex that are uniquely alike. They each have their own special characteristics, history, tradition, and personality. Thus what may appear to be a barrier to one company may not be considered a serious barrier to another company. Generalizations can, however, be made along with some observations concerning the perception and types of barriers that are encountered.

It is important to realize that barriers to the entrance into a given investment opportunity are subject to judgment. Barriers are perceived and subject to interpretation. Predicting how one specific company will react to a given policy designed to reduce the height of an investment barrier is extremely difficult if not completely impossible.

TWO TYPES OF BARRIERS Barriers can take the form of either absolute barriers that completely keep a company from making an investment, or they can be secondary barriers that influence the manner in which they make the investment. These secondary barriers may also be of sufficient size to restrict the company from making any investment whatsoever in the photovoltaic venture.

The absolute barriers can be thought of as being more definitive in their results in that they either allow an investment consideration to proceed forward, or it rejects it entirely. The secondary barriers tend to be more a matter of degree and center around the form of the investment.

ABSOLUTE AND SECONDARY BARRIERS There are basically two absolute barriers, one being low financial reward, the second being markets, products, or customers are not compatible with present company objectives. While there are several government programs that could be developed to reduce the low perceived financial reward barrier, there are few if any that can be developed for the perceived barrier of incompatibility with the photovoltaic venture.

The secondary barriers include such items as:

- High risk--technology
- High risk--market
- Attitude toward government presence
- Competitive environment
- Institutional issues
- Balance of systems cost

Except for the govermnent presence issue, virtually all of these perceived barriers can be positively influenced through various government actions.

POTENTIAL GOVERNMENT ACTIONS

There are many incentives that the government can use to induce industry into investment areas. Each of these incentives can also have a large number of variations such that their design can meet the special needs of each participating company. Extreme care must be taken, however, in their design in that they can easily bias the direction in which the market develops and selectively enhance and discourage specific companies.

DIRECT GOVERNMENT INCENTIVES AT FUNDAMENTAL BARRIERS In any venture, it is easy to identify those companies that would appear to be the most logical to participate in that venture, and it is also easy to design policies and programs around those companies. Through such policy designs, these companies become heavily involved in the

venture. It appears as though the policies were properly designed and attracted the proper companies. However, if the incentives had been designed to reduce barriers to investments, then it may have been found that a broader spectrum of better-qualified companies could have become involved in the venture.

It is thus critical and important that the government incentives be developed with care. In relationship to the photovoltaic venture, the most obvious companies to be involved would be the semiconductor-based companies. The technology for the photovoltaic venture is based upon the same technology and manufacturing techniques that have made the semiconductor venture so successful in this country. The semiconductor industry has associated with it, however, many deficits that will have to be overcome in some fashion to meet all of the requirements of the future photovoltaic industry.

There are other industry-type companies that have far greater assets available to be devoted to the photovoltaic venture than do the semiconductor companies. Even within those companies, there are some serious deficits which must be overcome. In order for the government not to bias the market toward the semiconductor industry or retard or eliminate some valuable resources in other companies, the government incentives must be carefully designed and directed at fundamental barriers to investments across the entire US industrial complex.

COMPROMISING OF RESTRICTIONS REQUIRED Preparing incentives not to bias the market and at the same time meet other boundary conditions, such as fostering small business or not overpowering normal market driving forces and competitive influences, will be virtually impossible. A compromise of all of these aspects is the best that can be accomplished.

NEGATIVE ACTIONS SHOULD BE AVOIDED There are also negative government actions that can bias the market away from certain types of companies and toward others. This could discourage investments from some of the better-equipped companies. Such a negative action would be that of imposing restrictions on the participation of petrochemical-based firms within the photovoltaic venture, or not recognizing other nonsemiconuctor-based companies would be seriously interested in the photovoltaic venture. Such companies would be those associated with thin-film technologies, equipment manufacturers, controls companies, glass and lead producers, and other industrial firms.

Other negative actions that must be guarded against are the implementation of legislation that dictates performance versus cost criteria. This is an area that should be left to the ingenuity and responsibility of private industry. Legislation must be implemented, however, to protect the public, but it should not dictate product design or performance criteria. It should, however, determine

standards of how performance can be measured and should include certain minimum aspects, such as building code requirements and safety aspects. Once government pursuit of performance versus cost criteria is evident, then industrial concerns will begin to lose interest in the venture, as they will feel they have lost control of their own destiny.

LONG-TERM GOVERNMENT COMMITMENT NEEDED Since the photovoltaic venture is a long-range venture, then it would be detrimental to the acceleration of the industrialization process for the government to pursue programs and policies based on only one-year commitments. Multiple-year commitments must be established in all incentives. Government commitments on a one-year basis do not allow for the gaining of confidence on the part of industrial companies that the government will be supportive of the photovoltaic venture in the following years. There must be longer-term commitments on the part of the government if long-term commitments are expected from industry, especially if the government's objective is to cause investments to occur sooner than they would normally. Thus, an excellent incentive based on too short a time span will be far less effective.

AVAILABLE INCENTIVES The available incentives include the following:

- Subsidize photovoltaic research and development
- Subsidize prices
- Guarantee market
- Experimental and demonstration projects
- Market studies
- Government-furnished equipment
- Management fee
- Production demonstration
- End-user financial assistance
- Supplier tax preference
- Loan guarantees to photovoltaic investors

MIXED REACTIONS WILL OCCUR TO ANY GOVERNMENT INCENTIVE An incentive designed at reducing investment barriers will be received differently by different companies, even within a similar industrial grouping. Each company has its own particular requirements and viewpoints of the height of the barriers to the investment. Two companies within the same industrial grouping with the same barriers will react differently to the same incentive because the barriers to investment will be perceived differently.

The difference in perspective of each of the investment barriers will vary due to differences in management style, philosophy of management, the available resources, their relationship to the government, previous investments, and investments that are competing for the resources of the company.

To meet the wide variability that exists within the American industrial complex, a group of incentives will have to be developed. No one or two incentives will accomplish the goals of the industrialization project. Not only will several parallel incentives have to be implemented, but there will also have to be a sequential application of incentives to account for the ever-changing conditions that will face prospective and present investors.

2. Study Objectives

2.1 STATEMENT OF PURPOSE

The industrialization of the photovoltaic venture refers to the commitment of resources on the part of industrial concerns in connection with implementing low-cost, high-production manufacturing techniques, procedures, and technologies to produce photovoltaic products. There are a number of options available to the government in the pursuit of industrialization.

In addition, there is a perceived need on the part of the government to accelerate this industrialization process. The reason for this study is to develop a detailed understanding of the decision process by which industrial concerns evaluate investment ventures in photovoltaics manufacturing.

The intended use of such a detailed understanding of the investment process would be to provide a framework by which the various government alternatives could be evaluated as to their likely influence upon stimulating or accelerating the industrialization process. The ultimate objective is, then, to provide a rank ordering of the various available government options and the reasoning as to their perceived influence.

2.2 TASK OBJECTIVES

Particular attention was paid to the influence on the investment decision of perceived financial reward, technical risks, and market risks associated with the photovoltaic venture. In addition, there had to be considerations made for the manner in which these perceived rewards and risks could be affected by rapid technological advances, successful or unsuccessful demonstrations of production or application technologies, and alternative government policies for industry stimulation.

The pursuit of the objectives of this study was divided into four basic task functions. A description of those tasks is as follows:

- Task 1--Industry Description and Potential Entrance Analysis

  Conduct an extensive industry interview program focused on companies which are presently participating in the photovoltaics market or which, because of their technology and past interest, could enter the market in the future. Particular attention was to be devoted to major semiconductor companies which have not yet committed resources to photovoltaics, as well as the US energy industry. All necessary precautions were to be taken to prevent disclosure of information proprietary to individual companies.

- Task 2--Investment Decision Analysis

  Integrate and condense into a usable, representative set the definable investment decision processes determined to exist in the companies interviewed in Task 1. Develop typical company groupings that represent the spectrum of present and potential photovoltaic suppliers. Identify from these groupings barriers to photovoltaic investments perceived to exist by potential entrants. Identify any additional barriers restricting expansion of present-day producers. Interpret the representative set of decision processes and perceived barriers as they influence investment decisions.

- Task 3--Industrialization Policy Design

  Select criteria for the evaluation of alternative government policies for stimulating the photovoltaics industry. Apply these criteria to a JPL-furnished list of government policies and programs. Prepare a preliminary rank ordering of these programs. Perform any resurveying necessary of selected companies to obtain their attitudes toward the

programs and policies as a calibration of the evaluation criteria. Incorporate results of the resurvey into a final rank ordering to be recommended to JPL.

- Task 4--Industrialization Measurement Criteria

  Develop from the understanding of investment decision proceses gained in previous tasks the conceptual framework necessary to monitor the commitment of industry resources to photovoltaic manufacturing. Define a set of leading indicators and recommend corresponding procedures to permit measurement in real time for the performances of this monitoring function.

3. Conceptual Framework for Decisions

3.1 DIMENSIONS OF UNCERTAINTY

INTRODUCTION OF CONCEPT

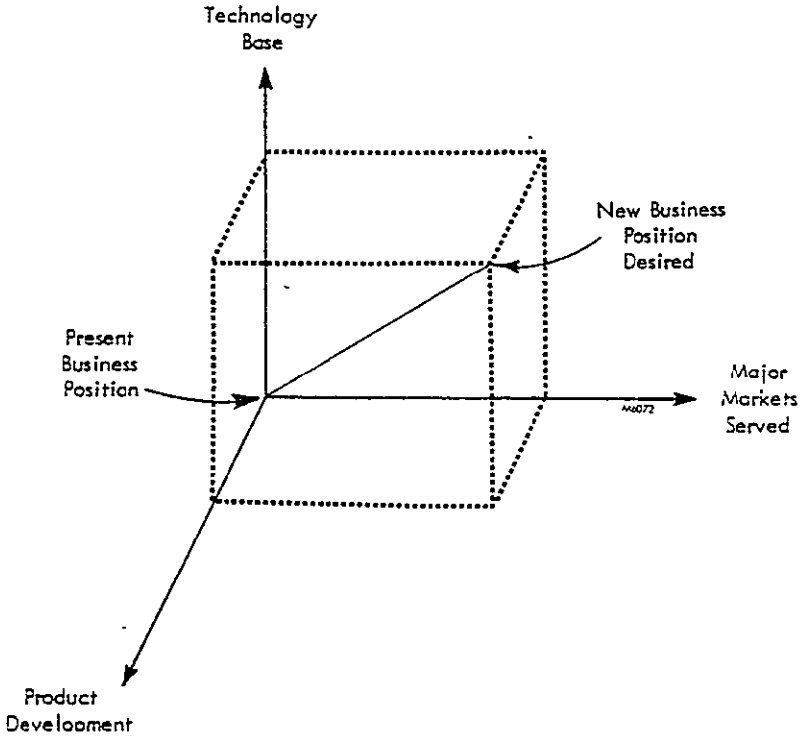
A company's business position and its relationship to a proposed investment venture can be characterized in many fashions: gross revenues, share of market, markets served, and financial perspective of the company, including past historical data as well as projected potentials for the company. None of these descriptions relate to the decision process or the characterization of how risk is evaluated and dealt with in a venture decision.

To understand the process by which companies arrive at an investment decision, a description of a company's business position is needed that relates to the characteristics and elements of a venture investment. One such description is portrayed in Figure 3.1. The origin of the three-dimensional figure represents the present-day business position of a company in regard to:

- Major markets served
- Product available
- Technology base

Any new business investment involves decisions concerning changes in these three major aspects of the company's present status. The degree of change in each element will vary, depending on the nature and size of the proposed investment. In effect, the investment would cause a change in the company's business position or status. Conversely, a change in business position will require an investment in at least one of these three major company business aspects.

FIGURE 3.1
CHANGE IN BUSINESS POSITION



ALL COMPANIES FACE SIGNIFICANT CHANGE In general, any company entering the photovoltaic industry will be changing its business position, since in most cases no previous activity would have existed in the photovoltaic area. Consequently, this calls for involvement in new markets using new products built with new technologies that were probably not employed by the company prior to entering the photovoltaic industry.

For companies in the photovoltaic industry, the expected changes in the photovoltaic industry will cause a change in their present business position. This will involve investments in product development, the establishment of new technologies, and in many cases include moving into new markets not presently served.

In the sections that follow, descriptions will be given of the impact and the significance of investments required in various combinations of these three basic elements of a business position. Distinction will be made between an enlargement of the present business position through larger market share of present markets and moving a company via investment to a new position involving change in the three major business aspects.

RISKS INVOLVED

A change in a company's business position includes the decision to invest, the actual capitalization of that investment, and an evaluation of risks. For any type of change in company position, there are always risks. These are the elements of the investment that cannot necessarily be quantitatively or analytically described. Judgment, courage, and determination on the part of the investing company are often required to arrive at a decision.

RISKS INCREASE IN PROPORTION TO CHANGES REQUIRED

Risks increase rapidly as the change in company position involves increasing components of each of the major business aspects. Changes in a business position that involve only one of the three aspects have lower risk as compared to changes in two or three major aspects of the business position. In each of the sections that follow, a separate discussion will be included on the implications of the risks associated with the proposed investment. Various methods of handling and evaluating risks will also be discussed.

RISKS INVOLVE LOST OPPORTUNITY AND OUTSIDE INFLUENCES

Risks not only involve the potential loss of the investment that is being proposed, but often include an evaluation of lost opportunities in other areas. There is no guarantee that a lost alternative would have been any more successful than the venture implemented. Thus judgment, perspective, and experience are elements that come to play in the investment decision in evaluating risks. In general, the more there is to be gained from a successful investment, the more there is to be lost if failure occurs.

The evaluation of risks also includes consideration of factors influencing the outcome of the investment that may not be under direct control of the company. Government regulations may be a significant influence upon the development of a market, and yet often no accurate forecast can be made of future government regulations. Such risk factors must be evaluated on a sensitivity basis, in which several scenarios are developed on outside influences and the resultant impacts upon potential success of the investment. Even with these sensitivity analyses, risk is often in the final decision evaluated strictly on a judgmental basis by the company senior staff.

3.2 IMPACT OF EACH DIMENSION ON DECISIONS

OVERVIEW

The following sections describe investments in a one- or two-dimensional movement to a new company position and their implications. Many investments move a company along only one of the three major axes describing a company's business position. Two-dimensional movements are also common but are usually associated with higher-risk investments.

The objective of these descriptions is to isolate individual dimensions and to emphasize critical points concerning investments along those single avenues. This will set the background for dealing with investments in all three dimensions at one time, which typically characterizes present-day investments in the photovoltaic industry. From these discussions will evolve the dominant characteristics of present-day investment philosophies and an explanation of how risk is dealt with in the investment decision process. Appropriate definitions and examples will be inserted to relate to present-day practices. Their intent is to illustrate the concepts being presented.

MAJOR MARKETS SERVED

DEFINITIONS

For the purposes of this report, major markets have been defined in broad terms, as exemplified in Table 3.1. This categorization includes not only markets served by electronic firms, semiconductor firms, chemical firms, and equipment suppliers, but also markets that potential photovoltaic suppliers will service in the near future or in the far term.

Not all of these markets can be served by every type of electronic, industrial, or photovoltaic firm. Each supplier of products or services has in general selected major markets found to offer the greatest opportunities. This is by no means a stagnant situation. Each company is constantly seeking new market areas in which they may participate that involve as low a risk and investment as possible. The more dynamic companies will, however, be seeking out opportunities in more of the major markets than the lesser dynamic companies. In addition, they will be pursuing a more aggressive expansion of their influence within presently-served markets.

TABLE 3.1
REPRESENTATIVE MAJOR MARKETS AND APPLICATION AREAS

ELECTRICAL/INDUSTRIAL EQUIPMENT

BUSINESS/RETAIL

- OFFICE EQUIPMENT
  - WORD PROCESSING
    - TYPEWRITER
  - CALC/ADD MACHINE
    - DESKTOP
    - ACCOUNTING
  - COPY/DUPLICATING
    - DUPLICATING
    - OFFSET
  - BANKING/FINANCE
    - COIN/CURR. HANDLING
    - AUTO CHECK WRITING
  - MAILROOM
  - PRINTING/PUBLISHING
  - OTHER OFFICE
    - ELECTRIC STAPLING
    - FORM HANDLING
    - OTHER
- RETAIL
  - CASH REGISTER
  - VENDING MACHINE

CONSUMER

- MAJOR APPLIANCE
  - KITCHEN
    - DISHWASHER
    - DISPOSER
    - FREEZER
    - RANGE/OVEN
    - REFRIGERATOR
  - HOME COMFORT
    - ROOM AIR COND
    - DEHUMIDIFIER
    - WATER HEATER
  - LAUNDRY
    - WASHER
    - DRYER
- HOUSEWARE
  - ELECTRIC
    - VACUUM CLEANER
    - FLOOR POLISHER
    - CLOCK
    - IRON
    - PORTABLE HEATER
    - FAN
    - SEWING MACHINE
  - KITCHEN HOUSEWARE
    - COOKING
    - FOOD PREP.
  - PERSONAL
    - BED COVERING
    - HEATING PAD
    - SHAVER
    - OTHER
- OTHER
  - CAMERA EQUIPMENT
    - STILL PHOTOGRAPHY
    - MOTION PICTURE
  - TIME PIECE
    - WATCH
    - WATCH & PARTS NEC
    - WATCHCASE
  - POWER HANDTOOL
    - ELECTRIC
    - POWER DRIVEN
    - OTHER

HOUSING & CONSTRUCTION

- PRIVATE CONSTRUCTION
  - RESIDENTIAL BUILDINGS
    - NEW FAMILY UNITS
    - ADDITIONS & ALTERATIONS
    - NON-HOUSEKEEPING
  - NON-RES. BUILDINGS
    - INDUSTRIAL
    - COMMERCIAL
    - RELIGIOUS
    - EDUCATIONAL
    - HOSPITAL & INSTITUTIONAL
    - MISCELLANEOUS
  - FARM
  - PUBLIC UTILITIES
    - TELEPHONE & TELEGRAPH
    - ELECTRIC LIGHT & POWER
    - GAS
    - RAILROAD
    - PETROLEUM PIPELINE
  - ALL OTHER PRIVATE
- PUBLIC CONSTRUCTION
  - BUILDINGS
    - HOUSING & REDEVELOPMENT
    - INDUSTRIAL
    - EDUCATIONAL
    - HOSPITAL
    - OTHER PUBLIC BUILDINGS
  - HIGHWAYS & STREETS
  - MILITARY FACILITIES
  - CONSERVATION & DEVELOPMENT
  - OTHER PUBLIC CONSTRUCTION
    - SEWER SYSTEMS
    - WATER SUPPLY
    - MISCELLANEOUS
- MOBILE HOMES

MACHINERY

- PRODUCTION EQPT.
  - METAL WORKING
  - WELDING
  - SPECIAL INDUSTRY
    - FOOD
    - TEXTILE
    - WOODWORKING
    - PAPER
    - PRINTING
    - OTHER SPECIAL
  - FARM
  - CONSTRUCTION & RELATED
    - CONSTRUCTION
    - MINING
    - OILFIELD
  - OTHER
- AUXILIARY EQPT.
  - MATERIAL HANDLING
  - PUMP/COMPRESS
  - REFRIGERATION
  - OTHER
    - SERVICE IND. MACHINERY
    - MEASURING & DISPENSING

ELECTRIC POWER

- GENERATION
  - BOILER & PARTS
  - TURBINE & PARTS
  - INTERNAL COMB.
- DISTRIBUTION
  - TRANSFORMER
  - SWITCHGEAR
  - LIGHTING
  - MEASUREMENT
    - AC WATT-HOUR METER
    - DEMAND METER
    - OTHER & PARTS
  - MOTOR/GENERATOR

ELECTRONIC EQUIPMENT

BUSINESS/RETAIL/EDUC.

- OFFICE EQUIPMENT
  - WORD PROCESSING
    - ELEC. EDIT. TYPEWRITER
    - DICTATING
    - MICROFILM
- BUS/SCI CALCULATOR
  - PORTABLE
  - DESKTOP
  - PROGRAMMABLE
  - ACCOUNTING
  - OTHER
- COPYWRITING/DUPLICATING
- BANKING
- MAILROOM
- RETAIL
  - ELEC. CASH REGISTER
  - ELECTRONIC GAME
- EDUCATION

COMPUTER

- CPU & MAIN MEMORY
  - MICRO COMPUTER
  - MINI CPU UNIT
  - SMALL GP CPU
  - LARGE GP CPU
  - OTHER CPU
    - ANALOG
    - HYBRID
- ADD-ON MEMORY
  - CORE
  - SEMICONDUCTOR
  - WIRE
  - OTHER
- DATA STORAGE
  - TAPE
    - I/O INTERFACE
    - REEL
    - CASSETTE
    - MASS TAPE
  - PRINTERS
    - IMPACT
    - NON-IMPACT
  - PLOTTER (PEN)
  - DISC
    - I/O INTEFACE
    - FIXED MEDIA
    - REMOVABLE MEDIA
      - FLOPPY DRIVE
- I/O EQUIP.
  - I/O INTERFACE
    - CARD I/O
    - DOCUMENT ENTRY
    - PAPER TAPE I/O
    - COM(MICROFILM)
    - OTHER
      - CRT
      - KEYBOARD
      - OTHER(BADGE)
  - COMM CNTL PERIPHERAL
    - AUDIO RESPONSE
    - MUX/CONCENT
    - COMM CNTL
    - PREPROCESS/MSG SW
    - MODEMS

COMMUNICATION

- TELECOMMUNICATION
  - SWITCHING
    - CENTRAL OFFICE
    - PABX
    - KEY SYSTEM
    - OTHER
  - TRANSMISSION
    - CARRIER
    - REPEATER
  - STATION EQUIPMENT
    - TELEPHONE SET
    - GADGETS
    - OTHER
  - WIRE & CABLE
  - TELEGRAPH EQUIPMENT
    - TELEPRINTER
    - OTHER
- RADIO COMM
  - AIRBORNE
  - MARINE
  - LAND MOBILE
  - AMATEUR
  - CITIZEN BAND
- MICROWAVE
- NAVIGATION
- BROADCASTING, CTV
  - BROADCASTING
  - CTV
- DATA COMM.
- OTHER
  - CCTV
  - TELEMETRY
  - FACSIMILE

CONSUMER ELECTRONICS

- HOME ENTERTAIN.
  - RADIO RECEIVER
  - TELEVISION
  - PHON/RECORDER
  - OTHER HOME ENT.
    - MUSICAL INST.
    - KITS
    - TOYS & GAMES
    - ACCESSORIES
    - VIDEO
- OTHER CONS. ELECT.
  - HOME ELECTRONIC
  - AUTOMOTIVE ELECTRONICS
  - PERSONAL
    - ELECTRONIC WATCHES
    - CONSUMER CALCULATOR

TRANSPORTATION

- MOTOR VEHICLE
  - PASSENGER CAR
  - MOTOR TRUCK & BUS
  - TRACTOR
  - REC. VEHICLE
  - PARTS & ACCESSORIES
- RAILROAD
- AVIATION
  - GENERAL AVIATION
  - COMMERCIAL & TRANSPORT
  - MILITARY
  - MISSILES
- BOATING
- SHIP
- MISCELLANEOUS
  - MOTORCYCLE
  - BICYCLE
  - SNOWMOBILE
  - GOLFCART
  - OTHER

INDUSTRIAL

- MACHINE/PROCESSING CONT.
  - MOTOR CONTROL
  - PROCESS CONTROL
    - CONTROLLER
    - POLLUTION CONTROL
    - OTHER
  - PRODUCTION TEST
    - CONTINUOUS PROCESS
    - PROCESS VARIABLE
    - OTHER
  - MEASUREMENT
    - TEMPERATURE
    - PROCESS DISPLAY
  - INDUSTRIAL HEATING
    - HF INDUCTION FURNACE
    - OTHER
- MATERIAL HANDLING
  - WELDING
    - ARC WELDING
    - ACCESSORIES
    - RESISTANCE WELDING
    - OTHER
- ALL OTHER
  - INTERCOMM. & ALARM
    - VEHICLE & PED. CONTROL
    - RR SIGNAL & CONTROL
    - INDUSTRIAL ALARM
    - INTERCOMMUNICATION
  - INDUSTRIAL POWER
  - ALL OTHER

INSTRUMENT

- TEST & MEASUREMENT
  - OSCILLOSCOPE
  - RECORDER
  - ANALOG INSTRUMENT
  - DIGITAL INSTRUMENT
  - ANALYZER
  - SIGNAL SOURCE
  - MICROWAVE
  - TESTERS
  - MEDICAL
  - ANALYTICAL
  - NUCLEAR
  - LASER
  - OTHER

GOVERNMENT/MIL

- RADAR
  - SEARCH & DETECTION
  - TRACKING
  - INSTRUMENTATION RADAR
  - OTHER
- GUIDANCE/CONTROL
  - MISSILE & SPACE
  - AIRBORNE, MARINE, GROUND
  - CHECKOUT & SUPPORT
  - OTHER
- COMMUNICATION/NAVIGATION
  - COMMUNICATION
  - NAVIGATION
- ELECTRONIC WARFARE
  - JAMMER
  - ELINT RECEIVER
  - WARNING RECEIVER
  - MULTIFUNCTION
  - OTHER
- INSTRUMENT/EDUCATION
  - INSTRUMENTATION
  - EDUCATIONAL
- DATA PROCESSING
- OTHER

DIFFERENCE BETWEEN NEW CUSTOMERS, NEW APPLICATIONS, AND NEW MARKETS
A distinction must be made between new markets, new customers, and new applications. Many examples of applications within a given market are listed in Table 3.1. For each application there may be many different customers, all within a given major market. Extension of products and services to new customers can occur within a given major market segment. Expansion of services and products to new customers is not considered to be an investment into new market areas.

The same product or service may be applied to a new application and to a new customer as well as to a new market. An investment in the one-dimensional direction of new markets served would not include any investment to be made in new products or new technologies. Thus in the context of this report, a new market served automatically requires new customers and possibly new applications but does not necessarily imply that new products or new technologies are required.

MARKET RELATIONSHIP TO PHOTOVOLTAICS Not all of the markets identified in Table 3.1 can be served by photovoltaic products. To relate the concept of markets to the photovoltaic investment venture, selected markets in which photovoltaics have reasonable penetration potentials are shown in Table 3.2, along with typical applications therein. For instance, the communications industry, especially remote repeater sites for communication channels, represents an excellent opportunity for photovoltaic products. The cathodic protection market also holds potential for photovoltaic products in well-head and pipeline applications.

RELATIONSHIP OF BUSINESS ASPECTS TO PHOTOVOLTAICS
The relationship between business position and major markets is demonstrated in Figure 3.2. Here the hierarchy of markets and applications, products, and technology are shown in their perspective as they relate to photovoltaics.

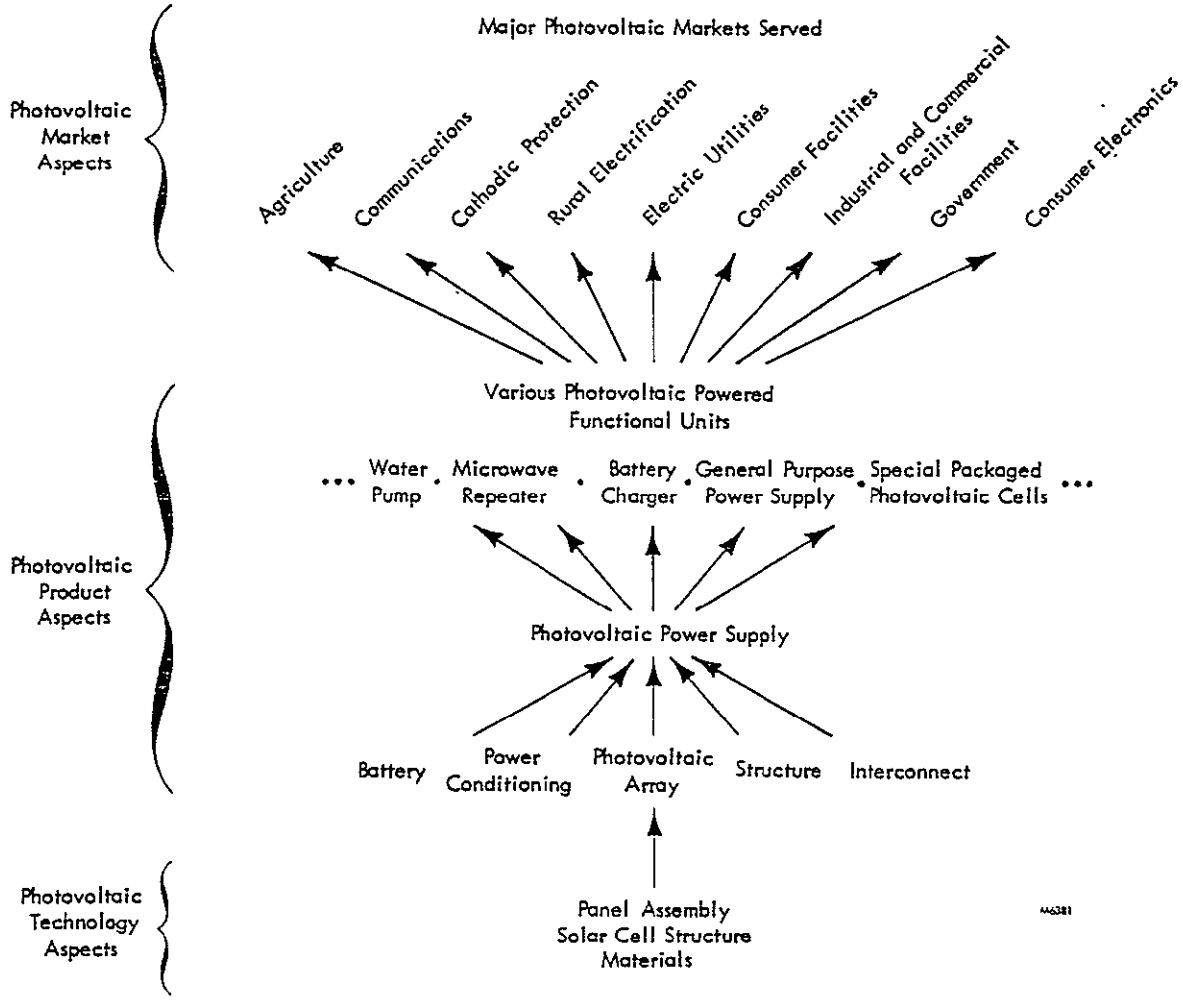
At the base of the hierarchy are photovoltaic technology aspects involved in assembly of photovoltaic panels or concentrator units, along with technologies of solar cell devices and materials involved. In general, this is the highest technology portion of the hierarchy.

The photovoltaic product aspects begin with the assembly of photovoltaic panels into photovoltaic arrays. Arrays are then coupled together with other components, including batteries, power conditioning, physical structures, and electrical interconnections, to form a solar power supply.

TABLE 3.2
POTENTIAL PHOTOVOLTAIC MARKETS
AND REPRESENTATIVE APPLICATION AREAS

Potential Markets	Representative Application Areas
Agriculture	Small water pumping Irrigation water pumping Distributive Deep well
Cathodic Protection	Gas and oil well heads Pipelines Transmission Distributive Bridges
Communications	Remote repeaters Diesel replacement TEG replacement Primary battery replacement New sites Navigational aids Telemetry
Consumer Electronics	Watches Calculators Recreational vehicles Battery chargers Backpacking
Electric Power	Central power generation Substations Distributed power generation
Government/Military	Portable field communications Water purification Remote installation power Test facilities Demonstration projects
Housing & Construction	Consumer facilities Single-family Vacation homes Commercial facilities Institutional facilities Industrial complexes
Rural Electrification	Lighting Water pumping Village industries Medical supply storage
Other	Electric vehicle Road signs Street lights

FIGURE 3.2
HIERARCHY OF MARKETS, APPLICATIONS, PRODUCTS AND TECHNOLOGY



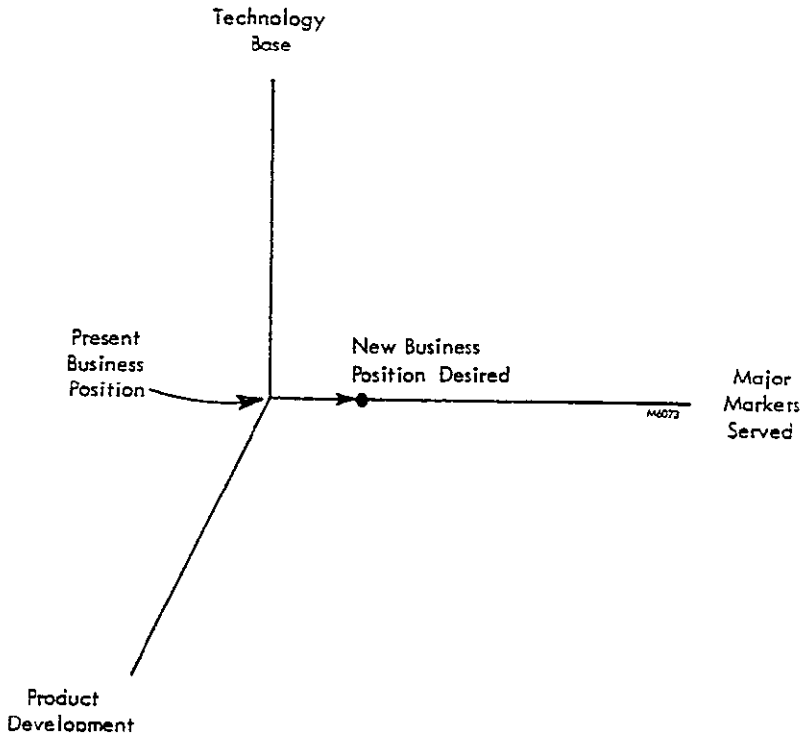
The solar power supply is then integrated into the design of a functional unit. Such functional units would include water pumps, microwave repeater sites, battery chargers, or special products such that the end result is a functioning unit that performs a useful service.

These photovoltaic products can then be applied to various applications within many market segments. A given product may be applied to several applications within one market segment or may be used in applications throughout several major markets. In general, a photovoltaic product will have been designed for a specific application within a given market, but through only slight modifications may find suitable application within other major market segments.

INCREASED SHARE OF PRESENT MARKETS SERVED USING ESTABLISHED PRODUCTS AND TECHNOLOGY BASE

Resources are often devoted to the concept of increasing a company's share of presently served markets. In the sense of this report, this is not truly a movement along any of the three major axes, but a redefinition of the origin of the business position. It could, however, under a selected set of conditions, be construed as a minor movement along the major markets served axis, as shown in Figure 3.3.

FIGURE 3.3
INCREASED SHARE OF MARKET



REPRESENTS LOW RISK The risk involved in making this movement is relatively low. Only minor investments need to be made, possibly an increase in the marketing staff or a slight increase in production if increased penetration is obtained. It does not include a risk in product development or in the development of a new technology, or even the risk of learning to do business in different market areas.

IMPLEMENTATION METHODS Incaeasing market share could involve nothing more than a lowering of product prices. The risk involved relates to the market price elasticity characteristics. If a reduction in price does not provide a significantly increased share of market, then the risk involved with price reductions was misjudged, resulting in lost profits. If the price elasticity estimates were correct, potentially large gains could be made through a simple price reduction.

Another example of implementing such a movement is special selection or categorizing of end products, such that higher prices could be exacted for the higher-quality portion of the product distribution. This, of course, assumes that the marketplace is willing to pay a higher price for a perceived increase in quality of product. This could lead to a larger share of at least the higher profit margin portion of the marketplace.

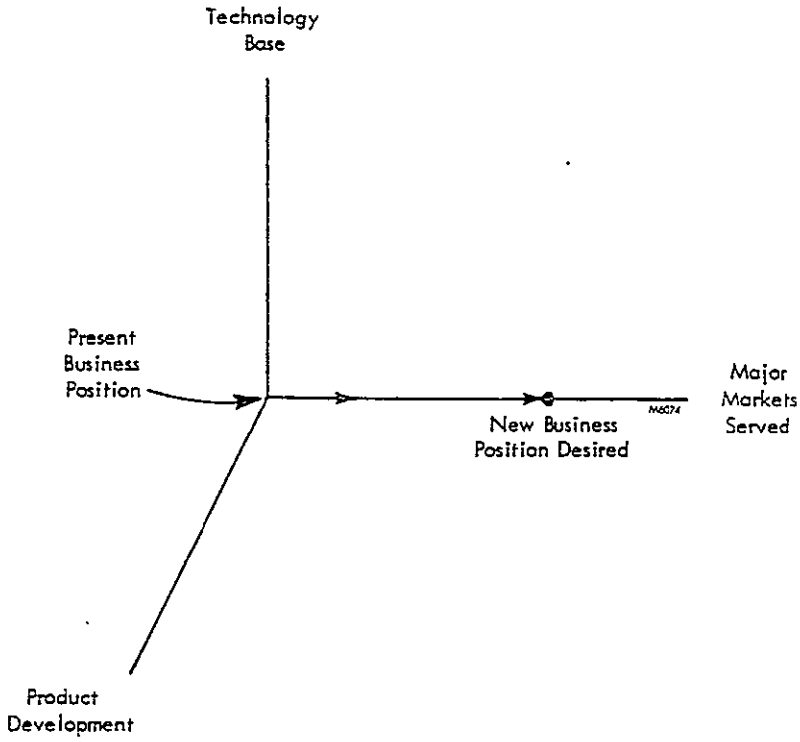
A third approach to increasing market share may be to increase the service aspect associated with supplying markets. Involvement of applications engineers with end-users, for example, could very well increase market penetration within those given applications. The product supplier performs some function for the end-user that would otherwise absorb end-user resources. In return, the end-user would purchase additional products from or pay higher prices to the supplier.

CONCLUSIONS Increasing market share in the context of this report is considered a conservative approach to business enlargement or a repositioning of a company's business posture. It involves little risk and virtually no investment in most cases. It is not typically characteristic of a new business venture, nor does it usually require a venture analysis.

NEW MARKETS SERVED USING ESTABLISHED PRODUCTS AND TECHNOLOGY BASE

By comparison to the previous example, this is a much more aggressive change in a company's business position, but is still a one-dimensional movement, as shown in Figure 3.4. By definition, this change involves enlarging a marketing staff and the development of new customers in entirely new market segments. Methods of doing business may be entirely different than from presently served markets. A company entering a new market segment often cannot cause a change in the way business is done. Therefore, they must learn the proper procedures, channels of distribution, and conform to them in order to be successful.

FIGURE 3.4
NEW MARKETS SERVED USING ESTABLISHED
PRODUCTS AND TECHNOLOGY



PENETRATION LIMITED BY PRODUCTS Companies are constantly seeking new markets for their products. This is a common occurrence throughout all suppliers of products and services. It involves taking the present-day products and the technologies on which they are based and moving them into new market areas, new applications, and new customers. Penetration into these new markets can be limited due to products not being optimally designed for the applications and the requirements of these new market areas.

An example is two-way communication equipment for the merchant marine marketplace. A decision may be made within a company to supply product to the aviation industry. Limited penetration will occur because the products for the merchant marine marketplace may not be packaged appropriately to fit the physical restrictions of an aircraft. This assumes only minor adjustments are needed for proper frequency ranges and other electronic requirements. Consequently, penetration will be limited because of the product.

MICROPROCESSOR TYPIFIES CONCEPT There are, however, many successful business ventures that involve the penetration of new markets with present-day products. An example of this is microprocessor circuits developed by the semiconductor industry for use in the computer market segment. It has been found that these products can be moved into the consumer electronics market with little change. Applications in consumer electronics include calculators, video games, microwave oven controls, etc.

Significant growth for microprocessors has occurred within the consumer electronics industry. Semiconductor companies have increased customer base, revenues, and shown substantial growth through the application of a standard product to a new market segment.

NEW MARKETS SERVED WITH NEW PRODUCTS USING ESTABLISHED TECHNOLOGIES

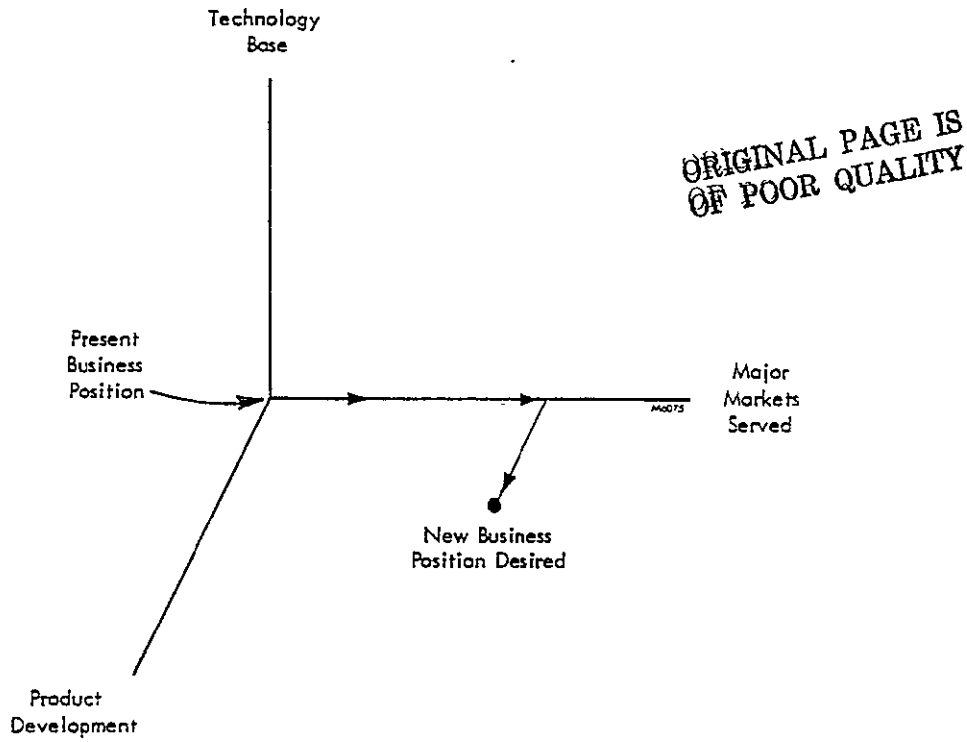
To enhance the potential for penetrating new markets, it is often required that new products be developed for the specific requirements of these markets. This is an extremely common occurrence within the semiconductor industry and requires in essence no new technologies, only a redesign of products around new application specifications. This approach is driven by participation first in new markets with established products, followed by the generation of new products designed for that market, as depicted in Figure 3.5.

RISKS INCREASE WITH INTRODUCTION OF SECOND BUSINESS ASPECT The risks involved in this approach are obviously much higher than simply the introduction of a standard product into a new marketplace. Here an investment must be made into a new product as well as learning how to do business in new marketplaces.

In many cases, the knowledge of application requirements in a new market may be lacking within a company. Consequently, the risks are increased that the product design for this application may be lacking some unique characteristic. In the development of a custom product for these conditions, there is also a risk that large-scale production orders that allow for the recouping of investment costs will not materialize.

SUCCESS ALLOWS SIGNIFICANT GROWTH However, if success is accomplished through this new product design for new markets, then significant growth in a company's business posture can result. In addition, the new products may bring insight into design characteristics for older products that would provide enhanced performance for the same price or even a reduced price, thus allowing increased market share in the older markets.

FIGURE 3.5
NEW MARKETS SERVED WITH NEW PRODUCTS
USING ESTABLISHED TECHNOLOGIES



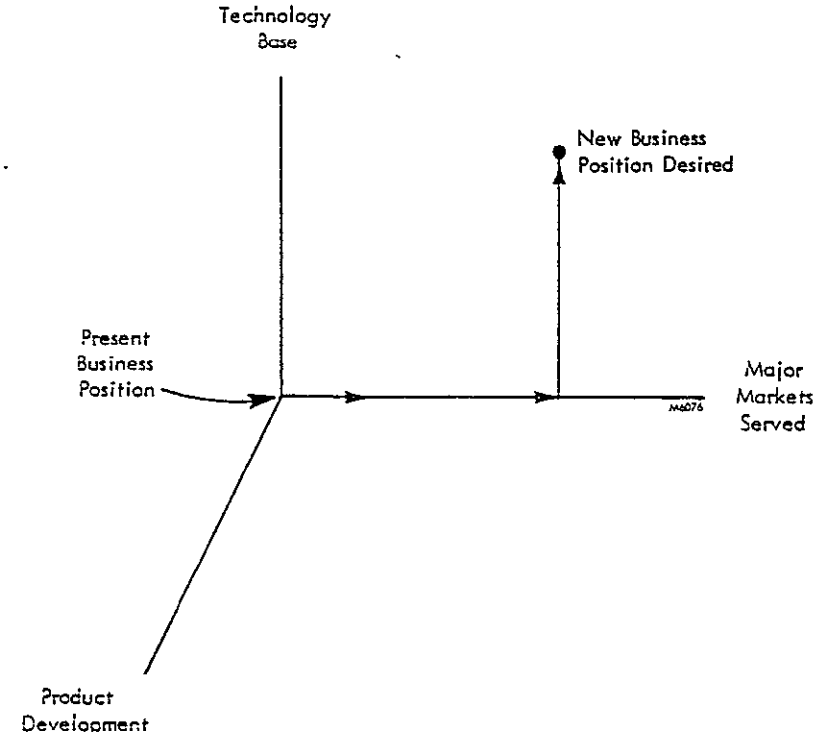
RISKS IN PROPORTION TO POTENTIAL The desire to penetrate new markets is the driving force behind the development of new products. If effective market penetration could be accomplished with established products, there would be no need to risk the development of new products. Judgment factors in estimating the potential of new markets, determining requirements for the development of products, and assessing whether or not large production orders can be obtained are involved in the risk evaluations that must be made in such a venture analysis. The market evaluation includes judgments on the price elasticity of markets, their ultimate sizes, and who the competition is. What do they offer that is unique or desirable to the end-user? Can new product concepts be brought to fruition in sufficient time to offset any development that the established suppliers in these new markets may be contemplating? What influence will an end-user's loyalty to present suppliers have upon the potential for penetration by a new supplier? Thus with the higher potential associated with high growth rates through this approach, there are also higher risks involved.

MARKET RISKS DOMINATE OVER PRODUCT RISKS Generally, the risks associated with the development of the new products is not as high as those associated with evaluating the potentials and the characteristics of the new markets. A company generally knows its internal capabilities very well and has confidence in its design and development groups, as well as knowing the capabilities of its production staff to gear up for a new product. There are many aspects, as previously pointed out, in the evaluation of the market characteristics that cannot be determined from industry statistics. The risks associated with the product development can, however, be more analytically examined. Those risks associated with the new markets to be served are generally in the qualitative area and must rely upon judgments and insufficient quantitative data.

NEW MARKETS SERVED WITH ESTABLISHED PRODUCTS USING NEW TECHNOLOGIES

Another possible method of penetrating new markets is to use established products and technologies followed by the introduction of new technologies. By definition, there is no change in product characteristics in this case. Arrival at this new business position is depicted in Figure 3.6.

FIGURE 3.6
NEW MARKETS SERVED WITH ESTABLISHED PRODUCTS
USING NEW TECHNOLOGIES



CONCEPT NOT A PRACTICAL ONE This is an unusual case however. The concept of changing a basic technology without any change in product characteristics offers no significant advantage to either the supplier or the user.

New markets will be serviced by what appears to the end-user to be the same product that was available prior to the development of the new technology. The manufacturer must invest in new technology, yet if it does not produce any significant new characteristics in the product, he has accomplished very little for the high investment risk in developing the new technology. Since there is no change in the product characteristics, the new markets to be served will see no advantage or may not even recognize that a new technology is involved. It will certainly pay no premium for the fact that it is a new technology and, in fact, may want to pay a lower price, as there will be a lack of field data and reliability information concerning this product using a new technology. It may be more difficult to increase penetration or remain viable in the new markets with products using the new technology than it would using established old technology products that have behind them reliability data and a number of field examples to demonstrate the product's characteristics.

In summary, the concept of a new business position involving new markets, followed by new technologies, but resulting in no recognizable product changes may not be a practical one. In fact, no examples of companies making such decisions is readily available or commonly known. Thus, while this new business position may exist in theory or within the context of the concepts presented here, in reality it appears to have no solid foundation to support that it actually exists.

APPROACH RESULTS IN USELESS TECHNOLOGY INVESTMENT

This change in business position could be typified by the hypothetical case in which a semiconductor company is servicing a given set of new markets using bipolar technology. To increase penetration of new markets, the company invests in the development of an MOS technology that is then applied to their products. The semiconductor company will have made the investment in developing the new MOS technology, which requires tremendous resources and new manufacturing techniques, but yet will offer no change in product characteristics to increase penetration of the new markets. It appears to be almost a useless investment in technology development, as it will offer little if any advantage to the end-user. The only possible gain is that as a result of the new technology, production costs can be substantially reduced. This would allow price reductions and possibly some associated increase in market penetration.

Besides being an almost useless investment in technology, there is little chance that the implementation of a new technology to old products can be accomplished without noticeable changes in product characteristics. Thus, arriving at this conceived new business position would be almost impossible, even if it were so desired.

P R O D U C T D E V E L O P M E N T

DEFINITIONS

Products are those physical items which a company ships to a user through various distribution channels and in return receives some financial payment or reward. The customer which receives these products may or may not be the ultimate end-user. The products may be combined with other components or other products to form a more complex or a higher value added end-product that is then distributed to end-users.

The number of intermediate handlers of the products can vary from zero to three or four independent operations. Generally, as these products move through the various channels of distribution, the handlers of these products either provide services or additional products that are combined with the original product to enhance the ultimate function or benefit that is provided to the end-user.

PHOTOVOLTAIC AND SEMICONDUCTOR PRODUCTS AS EXAMPLES

A typical product supplied by photovoltaic companies will be flat-plate photovoltaic panels which are then combined with other components or products, such as batteries, structural material, power conditioning equipment, and electrical interconnection material, to provide a photovoltaic power supply. This in itself is a product, but even this product will ultimately be combined with some other piece of equipment, such as a microwave relay tower or a water pump, to provide a functional product for some end-user.

In the case of the semiconductor industry, typical products would include the microprocessor, the random-access memory circuit, a read-only memory circuit, logic gates, operational amplifiers, and discrete semiconductor components. In addition to these basic products, the semiconductor industry also offers higher-level products which result from the combining of various semiconductor devices with other passive components, such as resistors and capacitors, on printed circuit boards. These products are basically functional products that fit into subsystems. Some semiconductor companies have integrated their operation such that these functional product boards are combined to form subsystems and subsystems are combined to produce end-products such as minicomputers or full-scale computers.

BASIC ELEMENTS OF PRODUCTS Products have three basic elements:

- Design
- Packaging
- Manufacturing processes and techniques

In the semiconductor industry, the design element relates primarily to the circuit design and the physical layout of the semiconductor chip. The packaging element relates to the material and configuration of the external package within which the semiconductor chip has been mounted and interconnected through appropriate lead mechanisms. Provisions must also be made for outside electrical contact to the product. The manufacturing processes and techniques associated with semiconductor products deal with variations within the manufacturing operation for chips, packaging, and the final testing of the product.

Within each of the manufacturing operations, there are a series of subtechnologies, processes, and manufacturing techniques that make up the overall technology base. Examples of subtechnologies are gold or aluminum wire bonding in the assembly operation and the use of negative or positive photoresist in device manufacture.

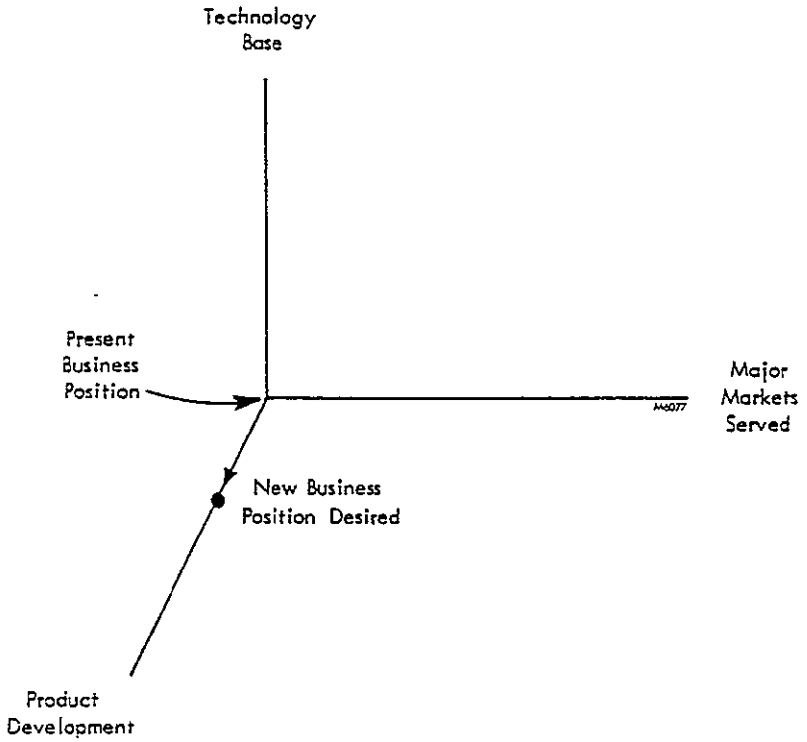
Further discussion of the concept of technology will follow. For the moment, it will be assumed that a series of subtechnologies, processes, and manufacturing techniques combine to form the basic overall technology that is used in manufacturing products. The significant point is that changes and evolutions in the subtechnologies, processes, and manufacturing techniques do not necessarily constitute a major change in the basic technology used by a company.

PRODUCTS EASIEST BUSINESS ASPECT TO QUANTITATIVELY DESCRIBE
Generally speaking, products are the easiest of the three major aspects of a company's business to define quantitatively and to analyze accurately. Products can be described through specifications, material content, and performance characteristics. Variations in these specifications can be directly related to financial investments and the required resources that must be brought together to formulate the change. Performance characteristics of products are generally the most difficult to guarantee early in the investment decision process. However, a significant amount of accumulated experience is usually available within the design and manufacturing staff to be able to effectively reduce the risk associated with meeting ultimate performance requirements.

PRODUCT DEVELOPMENT FOR PRESENT MARKETS USING ESTABLISHED TECHNOLOGY BASE

A common and continually evolving process within an industry is the development of new products for present markets using the established technology base within the company. This concept is shown in Figure 3.7. The intent is increased market share, to remain competitive, or to enhance the performance characteristics of the product line being supplied.

FIGURE 3.7
PRODUCT DEVELOPMENT FOR PRESENT MARKETS
USING ESTABLISHED TECHNOLOGY BASE



DESIGN ELEMENT CHANGE MOST COMMON OCCURRENCE Typically, this development takes the form of a variation on the design element as the principal area of change. This is very typical of the semiconductor industry. A read-only memory (ROM) is developed for a given series of applications. Through the variation of one or two design elements, a ROM can be designed for new applications within presently served markets or even new markets. It requires no change in the technology or the packaging concept but does enhance the variation in the types of applications to which it can be applied.

PACKAGING AND MANUFACTURING CHANGE CAN PRODUCE NEW PRODUCTS

A change in a semiconductor product's packaging concept would also constitute product development. Through a reorientation of the package leads, new applications could be serviced. The introduction of new packaging materials may substantially reduce product cost and allow a greater penetration of present markets. Repackaging may also allow the physical use of these products in areas not traditionally served. Repackaging may increase cost, but at the same time increase reliability. This would allow it to be used in high-reliability applications, such as military or harsh environment applications.

Changes in semiconductor manufacturing techniques and processes would generally be associated with attempting to increase the throughput yield or reduce the overall cost of the product to ehnance its penetration in present markets. Changes might include, for instance, automation of a manual step to reduce cost, or it may involve minor changes in assembly and a side result of enhanced performance. An example of this is a change in the temperature profile of the ceiling furnace used in the final processing of a semiconductor device. The end result might be higher yields plus a more hermetically sealed product, thus increasing its reliability and desirability in many applications.

PRODUCT CHANGES CAN CAUSE CHANGES AT CUSTOMER FACILITIES

Changes in products also may result in the removing of labor from the end-customer's facilities. As a result, the customer may be willing to pay a somewhat higher price, as it reduces his cost for labor. Sorting product through automatic testing procedures at the supplier's facilities could result in the elimination of an expensive incoming manual inspection procedure at the user's facilities.

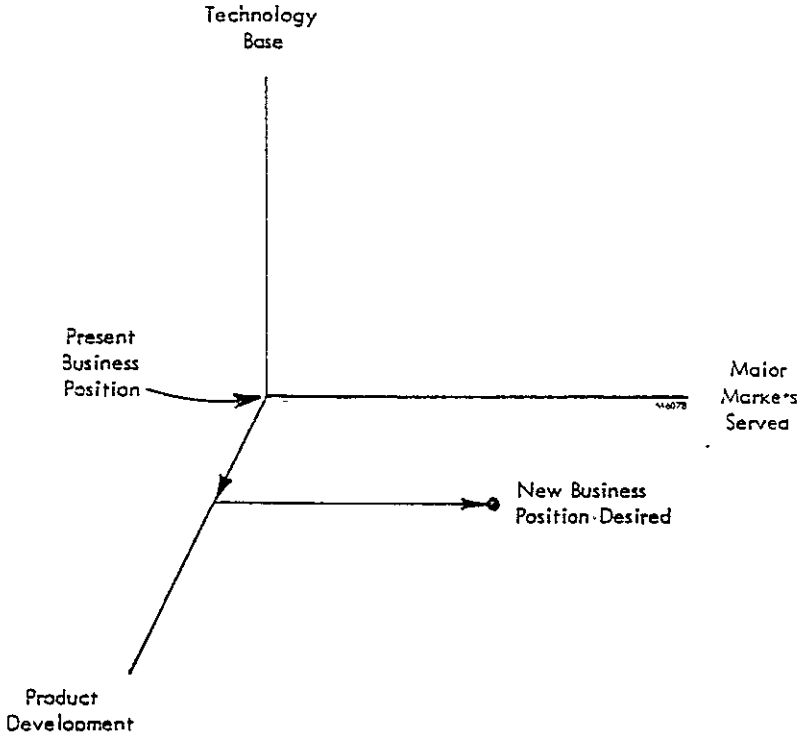
RISKS ARE RELATIVELY LOW AND CAN BE PUT IN FINANCIAL PERSPECTIVE

The risk associated with the development of products where no significant technology changes are associated is relatively low. As previously mentioned, it can generally be analyzed in great detail. The risk arises in properly evaluating the gains in the marketplace if such product development is implemented. The change in physical facilities and the number of design engineers needed to accomplish the product change, along with the scheduling of the new product and its introduction, is reasonably defined within a given manufacturer's facility. His accumulated experience in introducing new products is rather large in most cases, and his ability to quantitatively analyze the cost of such a venture is usually rather accurate. In summary, the technical risks associated with product developments can easily be put into financial perspective for the venture decision process.

PRODUCT DEVELOPMENT FOR NEW MARKETS USING ESTABLISHED TECHNOLOGY BASE

The concept of developing new products to penetrate new markets is very similar to the previous discussion of first entering new markets and then developing new products to enhance penetration. In that discussion, it was assumed that penetration was limited due to the limitations on the product. In this case, it is assumed that new products must be developed first to even approach the new markets. The movement of a company into a new business position by this route is shown in Figure 3.8.

FIGURE 3.8
PRODUCT DEVELOPMENT FOR NEW MARKETS
USING ESTABLISHED TECHNOLOGY BASE



MARKET REQUIREMENTS DRIVE PRODUCT DEVELOPMENT This adds a somewhat different perspective to the approach. The implication here is that the market has been so characterized as to indicate that competition is extremely fierce. To penetrate the market, a best effort must be set forth, which would require designing products specifically dedicated to special requirements.

It would imply also that the dedication or loyalty of the end-users to the suppliers would be great and that it requires a significant increase in product performance characteristics or significant cost reductions in products to make a penetration of the given market segment. Entering these markets with established products would be looked upon as a feeble attempt and would demonstrate a lack of understanding of the market characteristics by the supplier. A long-range implication of that approach is that even if a new product is ultimately developed, the supplier may have ruined his reputation within that market by first attempting to sell an inadequate product.

BOTH DESIGN AND PACKAGING CHANGE LIKELY TO OCCUR In almost all cases, a variation in both the design and packaging elements will be required to develop products for new markets. Again, these changes in the product are not beyond the scope of quantitative analysis. Thus the risks associated with such product developments are relatively low. Risks are encountered, again in the evaluation of the market characteristics, such as the price elasticity of demand and specific performance requirements.

AUTOMOTIVE INDUSTRY REQUIREMENTS TYPIFY CONCEPT This approach to a new business position is typified by the circuits being developed for the automotive industry. Here the semiconductor industry is using the same basic technologies that characterize their present-day product lines. However, due to the special requirements of the harsh automotive environment, new packaging techniques must be developed, along with variations in design to take into account the special performance characteristics that the auomotive industry is seeking.

Often this involves a custom circuit or a custom design. Supplying this product to the General Motors specification would in no way guarantee that it would meet a Chrysler specification. Standard products were not offered to the automotive industry because it was realized early that automotive requirements were unique in many fashions. Design teams from the various semiconductor suppliers thus met with the design and specification personnel of the automotive industry to develop custom products. These have evolved into large production contracts in several cases. Where standard products are being supplied to the automotive industry, it is generally associated with other custom products specially designed to complement standard products.

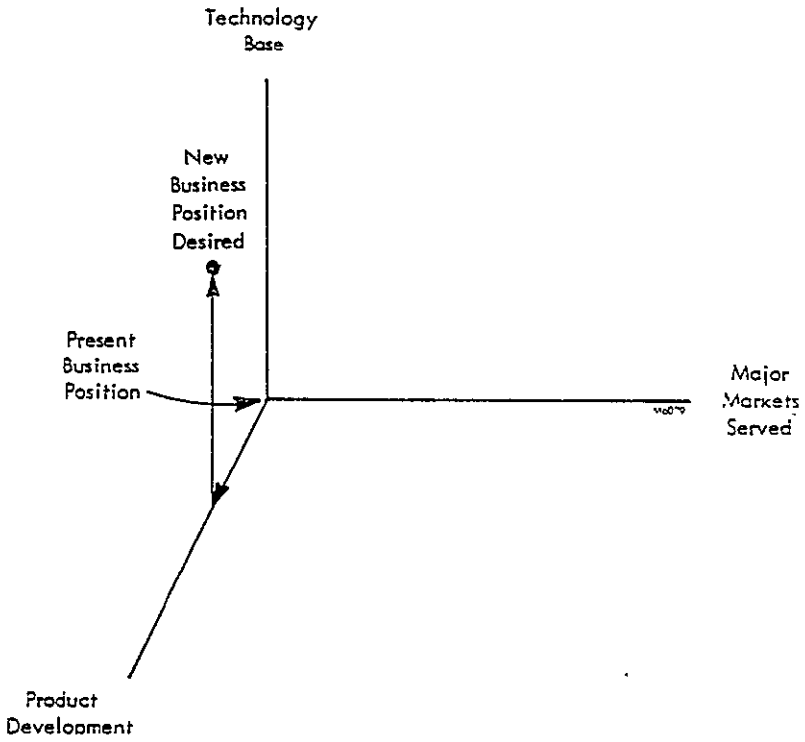
Associated with product development directed at the automotive industry is the risk that no long-term contract would develop, as several suppliers were attempting to meet the same set of specifications. In most cases, no product supplied met the entire specification, and consequently compromises had to be made in both the product performance characteristics and the automotive specification. Thus

it was a race between competing companies to arrive at an acceptable compromise position under the most attractive conditions for both the supplier and the automotive manufacturer. Here the risks were somewhat higher than in the previous cases mentioned because there was less guarantee that the return on the design investment would ever be recouped.

PRODUCT DEVELOPMENT FOR PRESENT MARKETS USING NEW TECHNOLOGY

Introducing a new technology into newly developed products for an established market, as shown in Figure 3.9, does not offer a significant advantage to the supplier unless the new technology results in significant performance improvement for the same price or a substantial reduction in cost for the same performance characteristics. However, the combination of new technologies and new products could offer a significant opportunity for an increase in share of market.

FIGURE 3.9
PRODUCT DEVELOPMENT FOR PRESENT MARKETS
USING NEW TECHNOLOGY BASE



There are very few examples of products being developed first for present markets, and then a new technology being introduced into those products. (The reverse of that situation in which new technologies are developed and then new products evolve out of the new technology base is quite common and will be discussed under the Technology section.) Where there is a technology development element involved in arriving at a new business position, it is more often a simultaneous development of technology and products rather than the serial development of first products and then new technologies.

In the case of the semiconductor industry, there was a signifcant market in the late 1950s for discrete semiconductor products. Around 1960, the planar process was developed. While this did add some additional new products to the discrete area, its greatest benefit resulted in the development of a whole new series of products called integrated circuits.

Within the photovoltaic industry, many new products will evolve to service established markets. However, when a significant new technology base is introduced (for example, the production of thin silicon sheets), it will undoubtedly result in a new series of products. It will not be incorporated into just standard products with very little product change. Product characteristics will change, physical layout of the product will change, material content will change, and probably performance characteristics will change.

T E C H N O L O G Y B A S E

DEFINITIONS

The technology base of a given company, in broad terms, is the collection of all of the subtechnologies, processes, and manufacturing techniques required to produce the company's products. In general, there are selected elements within this collection that give the technology base its predominant characteristics.

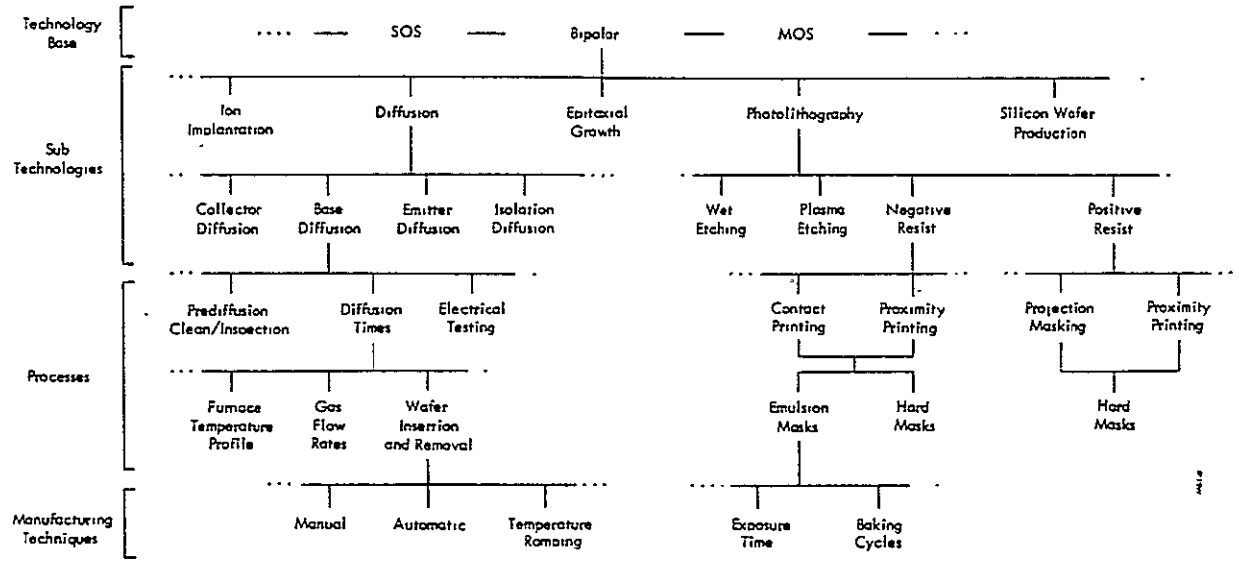
The semiconductor industry can be used to typify technology definitions and to distinguish between processes, manufacturing techniques, and subtechnologies.

A semiconductor production facility encompasses three basic areas:

- The manufacture of the circuit devices or chips
- The assembly of those devices into packages
- The electrical and environmental testing of products

Within each area, there is a series of subtechnologies that define and characterize the company's technology base. It is the inclusion of certain subtechnologies and the exclusion of others that determine the technology base characteristics. Within each series there will be certain subtechnologies that have the greater influence in determining the overall technology base characteristics. Generally, the dominant subtechnologies within an area can be changed without requiring substantial change in the dominant subtechnologies of the other two areas. A limited sample of the technology bases, subtechnologies, processes, and manufacturing techniques used in the semiconductor industry is shown in Figure 3.10. These examples are from the manufacturing area for circuit devices or chips, as this area has the most relevance to the photovoltaic venture.

FIGURE 3.10
DISTINCTION BETWEEN TECHNOLOGY BASE, SUBTECHNOLOGIES, PROCESSES, AND MANUFACTURING TECHNIQUES



TECHNOLOGY BASE COMPOSED OF MANY SUBTECHNOLOGIES

Some common technology bases in the semiconductor industry include bipolar, MOS (metal-oxide-silicon), and SOS (silicon-on-sapphire). Within each of these major technologies, there are a series of subtechnologies involved. One subtechnology is associated with diffusion or junction formation within the bipolar technology. Other bipolar subtechnologies are photomasking, epitaxial growth, and growth and manufacturing of the basic silicon wafers used.

SUBTECHNOLOGIES HAVE MAJOR AND MINOR COMPONENTS Each of these major subtechnologies is characterized by a series of lesser subtechnologies. In the case of diffusion, it includes those diffusions associated with collector, base, emitter, isolation, and a series of other minor subtechnologies. In the case of the photolithography subtechnology, decisions must be made as to whether to use wet or plasma etching or a combination of both, and whether or not to use positive or negative photoresist. It is the collection of these minor subtechnologies that characterize the subtechnologies.

MAJOR AND MINOR PROCESSES MAKE UP SUBTECHNOLOGY BASE Each of these minor subtechnologies has associated with it a collection of processes, both major and minor in nature. For example, the base diffusion in the bipolar technology base is composed of prediffusion clean and inspection processes, diffusion times, electrical testing, and several other processes. Each major process is characterized by a series of minor processes. For instance, the times required for base diffusion are a function of furnace temperature profile, gas flow rates, wafer insertion and removal processes, along with other requirements.

MANUFACTURING TECHNIQUES DESCRIBE PHYSICAL ACTIVITIES To carry out these processes, there must be implemented a number of physical activities which are defined as manufacturing techniques. For instance, the wafer insertion and removal processes may be manual in nature, or they may be automatic with the use of certain equipment.

DIFFERENT TECHNOLOGY BASE HAS DIFFERENT COMPOSITION OF ELEMENTS If, instead of bipolar, the MOS base technology were selected, a different composition of subtechnologies, processes, and manufacturing techniques would have to implemented. Still another set of such items would have to be implemented if the SOS technology were to be the base technology for a given company. Many elements described in the bipolar process may be entirely suitable for use within these new technology bases. However, the specific collection required for the bipolar technology base could not satisfy the requirements of the base technology in MOS or any other base.

MULTIPLE TECHNOLOGY BASES LESS COMMON Most semiconductor companies have selected some major technology base upon which they have founded all their product lines. The larger semiconductor companies, such as Texas Instruments, Fairchild, and National, have implemented more than one. However, each of these large companies began with only one technology base. Through expansion of their resources, they have implemented parallel departments that are dedicated to the use of some of the other technology bases.

Even within these larger companies, there is still a dominant technology base that exemplifies the majority of their products, even through there may be a collection of several technology bases. In addition, there are always separate manufacturing facilities associated with each technology base in these larger semiconductor firms, heavily implying that it is not likely that a mixture of two technology bases can be satisfactorily operated within the same manufacturing facility. Thus if a semiconductor company is heavily based upon bipolar technology, it is unlikely that an MOS technology base could be implemented within the same physical facilities as houses the bipolar process.

DESCENT OF HIERARCHY ALLOWS INCREASED CHANGE BUT LOWER INVESTMENT

Within the hierarchy of the technology base, which includes the subtechnologies, processes, and manufacturing techniques, it is noted that the further down in the hierarchy one proceeds, the more flexibility and likelihood of evolutionary changes will occur. For instance, manufacturing techniques will constantly be changed and implemented as new ideas are generated. However, it is very unlikely that a company will ever change from a bipolar technology to an MOS technology or conversely.

There have been several attempts within the semiconductor industry to make a major technology base change which have, in general, met with failure. Only a few companies have been able to implement parallel programs, such as bipolar and MOS technologies. Few other companies have been successful or have the capital resources to even contemplate such a development.

While manufacturing techniques may continually be in a state of flux, there is a certain solidarity and stability associated with the processes. For instance, prediffusion clean and inspection may have some technique changes associated with it, but it is unlikely that removal of the prediffusion clean and inspection step will occur, or that the implementation of a prediffusion clean and inspection operation will be needed if it has not been needed in the past. In other words, process changes occur much more slowly than do changes in the manufacturing techniques.

Subtechnology changes are even more rare than process changes. For instance, once a company has decided that diffusion technologies will be used to formulate the P-N junctions, it is unlikely that ion implantation will be implemented. Only after a thorough investigation of ion implantation has been done and a proposed product taking advantage of ion implantation has been conceived is a company likely to implement this new subtechnology. In no case will all of the diffusion technologies be eliminated and replaced by ion implantation. However, what may occur is the establishment of ion implantation capability and then a slow evolution of its use within new product designs until each of the diffusion processes has been replaced by ion implantation. Thus long-range evolutionary changes will characterize subtechnology changes.

The same can be said concerning the use of positive resist if historically the company has been using negative resist subtechnologies. The implementation of positive resist carries with it a change in the masking processes, it changes the entire mask layout procedure, and it is usually associated with a change in the type of mask used. All of these implied changes require significant capital investments and are thus slow in being implemented. In addition, they must have specific rewards available to justify their implementation.

Thus as one moves down through the hierarchy of the technology base, one finds increasing opportunities for evolutionary changes occurring; but at the same time there is a decreasing investment required associated with these changes. Conversely, going up through the hierarchy of the technology base, one finds an increasing reluctance to change and larger capital investments required for changes.

TECHNOLOGY OBSOLESCENCE

To date, there have been many manufacturing techniques that have been obsoleted, and in some cases there have been processes that have been obsoleted. By this it is meant they are no longer in common use. They have been replaced by less expensive or more efficient processes and manufacturing techniques.

The subtechnologies, however, have generally not been obsoleted, but they are changing in their relative dominance. As an example, diffusion subtechnologies are being replaced by ion implantation subtechnologies in selected companies.

RELATIVE POSITION OF TECHNOLOGIES IS CHANGING To date, no technology base in the semiconductor industry has completely obsoleted other technology bases. In the case of the MOS technology, it has been gaining over the bipolar technology base in the number of new circuits being introduced and the dollar volume associated with sales in the semiconductor industry. It does not mean that it is replacing the bipolar process. It simply means that the marketplace for the products built with the MOS technology base has a more rapid growth. To a large extent, this is based upon the fact that MOS technologies offer higher densities in product functions than does the bipolar technology base. Consequently, cost can be reduced using the MOS technologies. However, the bipolar technologies offer significant advantages in many cases associated with the speed at which digital and analog functions can be performed. Thus it depends upon requirements of the marketplace as to whether speed or low cost through circuit density is the more dominant issue.

The SOS technology has been making slow but steady progress over the last five years. The potential of SOS is in the area that it offers extremely higher-speed devices than the bipolar processes offer. However, the expense associated with the growth of the sapphire substrate and the inability to develop successful subtechnologies for the growth of the silicon epitaxial layers has restricted the use of the SOS technology.

OBSOLESCENCE IS A MATTER OF DEGREE Thus technology obsolescence is a relative matter, or a matter of degree. In certain market areas, the bipolar process has become obsolete and has been replaced by the MOS technology. In other product areas, the bipolar technology is associated with continually growing markets.

OBSERVATIONS CONCERNING NEW TECHNOLOGIES

Before entering a detailed discussion of investments in new technologies, some comments can be made concerning introduction and implementation of such technologies.

NEW TECHNOLOGY DRIVES PRODUCT DEVELOPMENT A new technology will virtually always drive the development of a series of new products. A new technology is seldom developed strictly for cost reduction. A process, however, may be changed or implemented to reduce manufacturing costs. Subtechnologies are introduced to allow improvements in product characteristics and reduce costs. With the introduction of new technologies or subtechnologies, there is set in motion a product development program to take avantage of the capabilities of these new technologies. It may be in parallel or after the fact, but it will inevitably occur.

NEW TECHNOLOGIES ASSESSED THROUGH NEW PRODUCTS New technologies are usually developed in parallel with a new product that will test the characteristics and limits of that new technology or new subtechnology. The development of a new technology or subtechnology often adds greater capabilities to the manufacturing operation and opens new horizons in the area of product performance or product characteristics.

It is often impossible to know the exact characteristics of a new subtechnology or technology without applying it to a product. The reason for this is that changes in the subtechnologies often interact with other subtechnologies, resulting in entirely unexpected characteristics. Thus to know the full effect of the subtechnology changes, a product must be designed and used during the development phase to verify all of the interrelationships between the various subtechnologies

In the case of a new technology base, very little actual data or information may be available within a given company concerning its complete capabilities. Only through the application of the new technology to a product or series of products can this be accomplished.

NEW TECHNOLOGIES APPLIED FIRST IN PRESENT MARKETS

New technologies are often applied first through products sold in established markets for testing before introducing the technology and the products into new markets. Through introducing the new technology into known markets, previous history and reaction of that marketplace to the standard products acts as a gauge by which the new technology and its influence can be measured. In addition, if there is a negative aspect to the new technology, as may be noted through reduced performance characteristics or reliability problems, the reputation of the supplier within a given market is not totally ruined because he has an established background and a back-up product. However, if the new technology is applied through products to new markets and failures occur, then very long-lasting ill effects could exist within those new markets. This could restrict the penetration of the supplier at a later date, when he has resolved the reliability problems. Thus present markets are often used to test the characteristics of the new technology.

PERCEIVED STABILITY CONTROLS AUTOMATION OF NEW TECHNOLOGY

The willingness to automate a new technology concept is dependent upon the perceived stability or maturity of the new technology within a given timeframe. For instance, if the technology appears to be safe and secure for the next five years, automation may take place. However, if it is perceived that an even newer technology may replace the present new technology within two years, then automation will not take place unless influenced by government policies. Such a policy would be rapid depreciation, such that the investment could be recouped within the two-year period. In that case, it may be well worth the implementation of automation for that new technology.

The perception of the stability and maturity of the new technology can be influenced not only by government policies, but also by competition and market growth characteristics. If extremely rapid market growth is envisioned by a given company, then the investment in automation may occur, the reasoning being that the volume of production will be such that the investment can be recouped. This may not be the viewpoint of all suppliers. Strong technology competition may cause a company to be reluctant to automate. Conversely, weak technology competition may lure companies into early automation.

The perception of market conditions, future government actions, and competition can heavily influence trends in automation. The timing of the automation can also be affected by availability of appropriate equipment. If long design and lead times are required for equipment deliveries, then the willingness to commit to automation will be weakened if the perceived stability time frame is short.

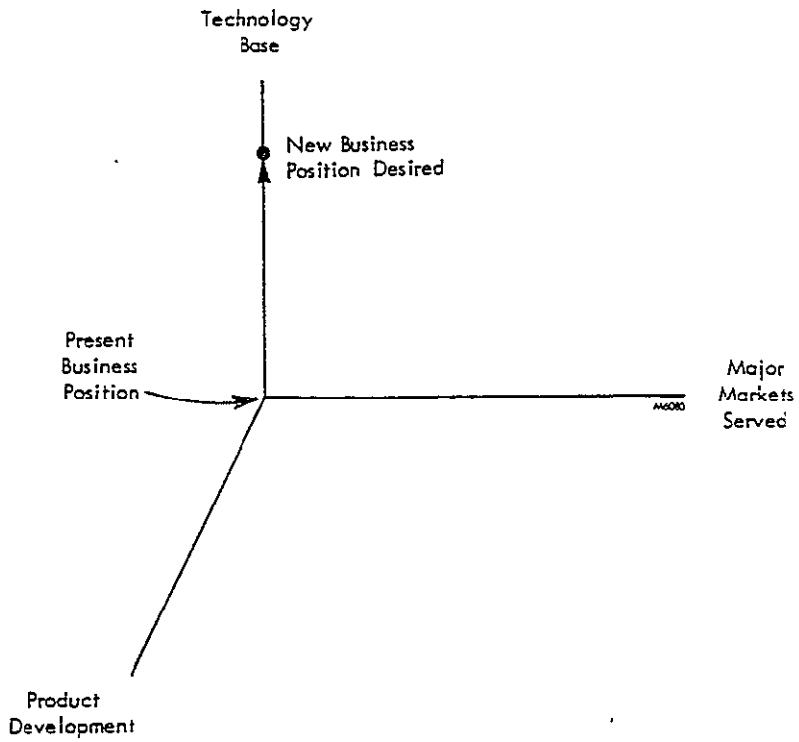
NEW TECHNOLOGY APPLIED TO ESTABLISHED PRODUCTS AND MARKETS

The movement of a company to a new business position along the technology base axis is demonstrated in Figure 3.11. The objective of such a move is to increase or enhance product performance and/or implement cost reduction processes. In effect, a company may pursue this route to remain competitive within present markets, but it will not necessarily guarantee a rapid growth situation within those markets. The growth rate of the company will depend more upon the characteristics of the markets being served rather than the technology base. The new technology base, however, could allow a company a rapid market share increase, but only for a restricted time, as it is most likely that the technology base change that was implemented will also be implemented by other competitors.

A distinction must be made between implementation of a new technology base or a subtechnology and implementation of process changes and manufacturing techniques, as demonstrated in Figure 3.10. The implementation of process changes does not represent a movement along the technology base axis. In addition, the degree to which subtechnologies are implemented may or may not represent a significant change in the technology base. If only one new subtechnology is implemented, it is not likely to represent a significant change in the technology base. However, if a series of new technologies are introduced, then this could represent a change or evolution in the company's technology base, as used in the context of this report.

RISKS ARE IN PROPORTION TO CHANGE The risks associated with the movement along the technology base varies with the degree of the technology change. In the case of a semiconductor company, change from a bipolar technology base to an MOS technology base involves extremely high risk. In addition, if the same products are to be supplied and the same markets are to be served, there is very little reason to believe that this technology change will be financially successful. There are no known cases where a semiconductor company has changed basic technologies and survived financially. There are cases, however, where additional technology bases have been added.

FIGURE 3.11
NEW TECHNOLOGY APPLIED TO ESTABLISHED
PRODUCTS AND MARKETS

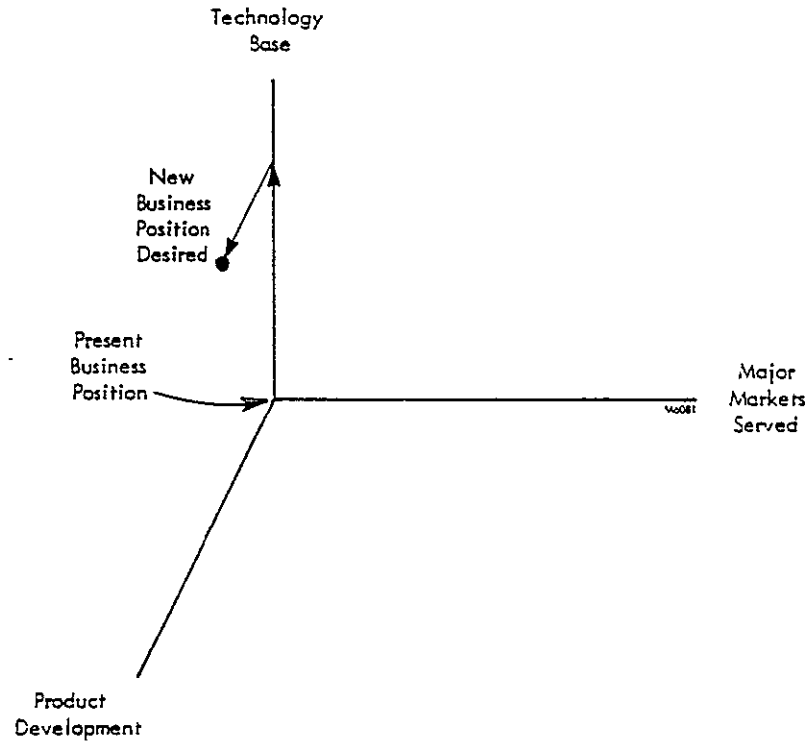


TECHNOLOGY CHANGE BY ITSELF UNLIKELY There is little evidence to support the idea that a company would implement a new technology base to just gain market share. Market share gains may result from a new technology base, but will not be the driving force. Due to the extremely high risks associated with new technology bases, there must be some additional element behind such an implementation. Remaining competitive may be the primary driving force for this type of a movement, or a desire for a long-range change in a company's business position. Thus the implementation of new technology bases will be coupled with the development of new products and/or the penetration of new markets.

NEW TECHNOLOGY AND PRODUCT DEVELOPMENT APPLIED TO ESTABLISHED MARKETS

The simultaneous development of technology and products, as demonstrated in Figure 3.12, is a common occurrence. The development of the technology base does not imply the obsolescence or the replacement of older technology bases. It implies the addition of new technology bases or a series of subtechnologies to the company's overall capabilities. Within the semiconductor industry, this is the most common method of developing a new technology base or implementing subtechnologies, namely to couple it with the development of a new product. These products will, in general, be directed at presently served markets but may also have outside application.

FIGURE 3.12
NEW TECHNOLOGY AND PRODUCT DEVELOPMENT
APPLIED TO ESTABLISHED MARKETS



SHARE OF MARKET GAINS ENHANCED This technique of technology and product development offers significant opportunity for an increase in share within presently-served markets. The reason is that product performance, and often product cost reductions, can be implemented. Consequently, share of market increase can be accomplished.

TECHNOLOGY CHANGE MORE RISKY THAN PRODUCT CHANGE The risks involved are primarily associated with the development cost of the new technology capabilities. As previously discussed, the costs of new product development are relatively low and can be treated analytically. The development of a new technology, on the other hand, can be a never-ending process. The characteristics of the new technology also may not be those originally envisioned.

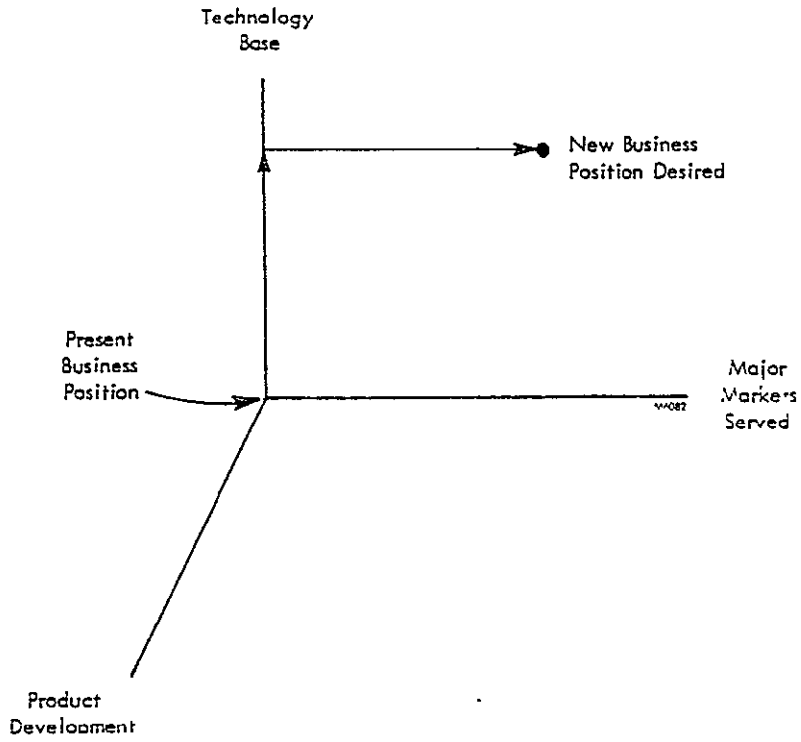
The establishment of a new technology may require technological breakthroughs that will consume millions of dollars as well as many man-years of effort. In addition to the direct costs and time involved, there is always the possibility that a competitor will be successful at an earlier date with an even better technology that would reduce the effectiveness of the one being pursued. These risks can only be offset by the future potential of the combination of the technology and new products associated with enhancing the development of new applications in the established markets presently being served.

The type of movement referred to in this section is exemplified by the semiconductor industry in the development of a new MOS technology referred to as the HMOS, or high-performance MOS, technology base. The technology base is the MOS technology, but associated with it are several significant new subtechnologies. The coupling of these new subtechnologies with the remaining older MOS subtechnologies produces a base technology with uniquely different characteristics, capabilities, and potential. To take advantage of the new subtechnologies, new products are also being planned for development that will hopefully open up new types of applications within presently served markets. It is through this means that the recouping of the investment costs must occur.

NEW TECHNOLOGY APPLIED TO PRESENT PRODUCTS DIRECTED FOR NEW MARKET

This new business position was previously discussed in the section on major markets served. The concept here is that a new technology base is implemented to allow the penetration of new markets, as shown in Figure 3.13. The new technology, however, must be implemented within the present product definitions. This limits the development of the technology (compared to following technology

FIGURE 3.13
NEW TECHNOLOGY APPLIED TO PRESENT PRODUCTS
DIRECTED FOR NEW MARKETS



development with new products) due to the restrictions implied by the present products. The new markets being served will envision the product in the same light as they envisioned the products prior to the implementation of the new technology, as the product characteristics will not be significantly changed.

HIGH RISKS WITH NO ADVANTAGES This combination of technology development and penetration of new markets combines the two highest-risk aspects of the concept used to describe a change in a company's business position, namely market development and technology development. Technology changes generally offer higher risk than product changes from a reliability viewpoint.

The combination of new technology changes and new markets could ruin the image of the supplier in the new markets, as previously discussed, with long-lasting effect, even after the problems are resolved. As a result, movement to this new business position generally offers no significant advantage to the supplier or the user.

3.3 SIMULTANEOUS IMPACT OF UNCERTAINTY DIMENSIONS ON DECISIONS

OVERVIEW

Previous discussions have centered around the sequential development of no more than two major aspects of a company's business position. There are, however, investment opportunities in which all three major aspects must ultimately be pursued. The pursuit may be strictly in a serial fashion or may involve a combination of simultaneous developments.

RISKS AND UNCERTAINTIES NOT COMPLETE BARRIER TO INVESTMENTS Movement in a three-dimensional environment will compound the risks involved, complicate the decisions, and cause the investment to increase many times. It can also spread the company's resources to the danger level in attempting to accomplish too much in a short time. Since ventures requiring simultaneous movements in more than one business aspect do occur, then it can be concluded that uncertainties associated with such investments are not complete barriers to high-risk ventures.

MANY ROUTES AVAILABLE TO NEW BUSINESS POSITION There are several routes by which a company may arrive at its new desired business position. Each has its own characteristics, including advantages and disadvantages and methods of handling risk. The particular route that a company may follow can be heavily influenced by government activities, competition, previously established company resources, and changing market conditions.

The routes by which a company can move to a new business position include:

- The direct route
- The series development route
- The combined development route

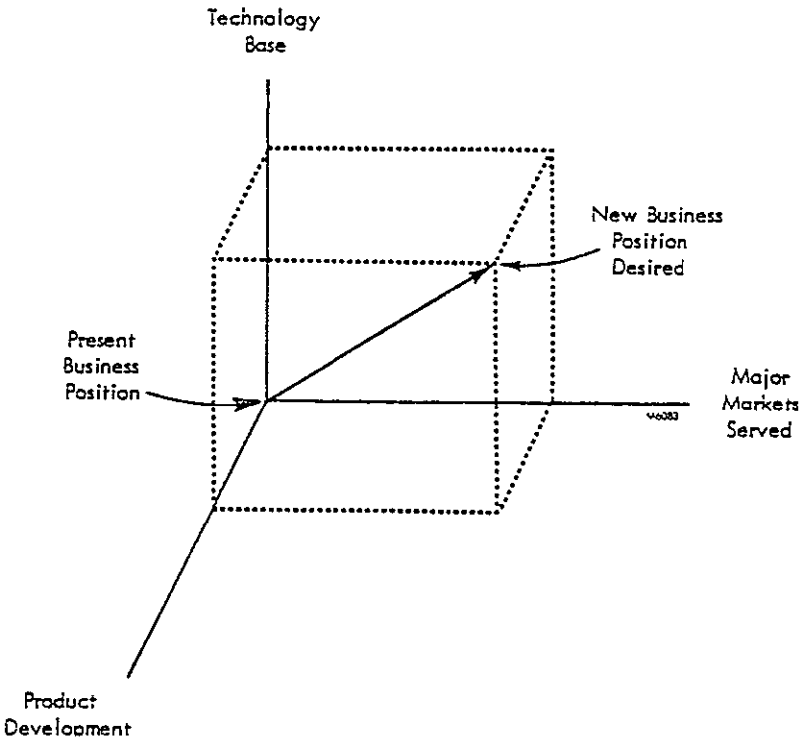
There is no reason to believe that a company must remain upon one of these particular routes once they have begun to move into an investment area. It may be that through the obtaining of additional data and information an entirely different route will be selected midway through the venture to complete the final stages of the investment.

METHODS OF HANDLING THREE-DIMENSIONAL RISKS

DIRECT ROUTE

To move into a new business position by the direct route is illustrated in Figure 3.14. The intent is to invest in all three aspects of the business position simultaneously. The direct route implies that a company has concluded they have tremendous resources and sufficient information in all three aspects to successfully accomplish the required tasks.

FIGURE 3.14
DIRECT ROUTE



HIGHEST-RISK APPROACH This is the highest-risk route, especially if only company resources are being used. This requires investments to be made in technology, product, and market development simultaneously. Thus all of the risks associated with each of these aspects are compounded and require a tremendous coordinated effort within the company to keep the total investment to a minimum. Pursuit of this route often increases the overall investment because of the lack of timely feedback from market inquiries to influence product development. In addition, commitments within the marketplace may be made that cannot be supported as a result of a slower product or technology development than originally assumed.

ACQUISITIONS CAN REDUCE INVOLVED RISKS Pursuit of the direct route is usually associated with an acquisition or a series of acquisitions. Through the acquisition, many things can be accomplished simultaneously. The acquisition of a company already in the newly desired markets provides a foundation of customer contacts, knowledge concerning the customers' needs, and pricing information, including price elasticity data. Depending on the nature of the acquisition, a product and manufacturing technology base can also be acquired.

The products may need modifications, and there may need to be additional money spent on automation or updating of the technology base, but the foundations of such technology requirements and product knowledge are usually readily available within the acquisition. This reduces the risks associated with the total investment. Given a solid foundation, often only a slight additional investment in selected areas of the acquisition can result in tremendous returns.

SERIES DEVELOPMENT ROUTE

In contrast to the direct route is the series development route, in which a new business position is obtained through a series of developments. Typically such a sequence would be the development of a technology base, then products, then the development of new markets, as typified in Figure 3.15a. This is the most frequent approach if only company funds and internal development activities are to be used.

There are several alternative series routes that can be pursued, as shown in Figures 3.15b, 3.16, and 3.17. The pursuit of the route described in Figure 3.15b, in which first a technology base, then new markets, and finally new products are pursued, is not a common approach. The series development of first a technology base and then new markets was discussed in previous sections and was determined to be an inappropriate or inadequate and virtually nonexisting route.

FIGURE 3.15
SERIES ROUTE - TECHNOLOGY DRIVEN

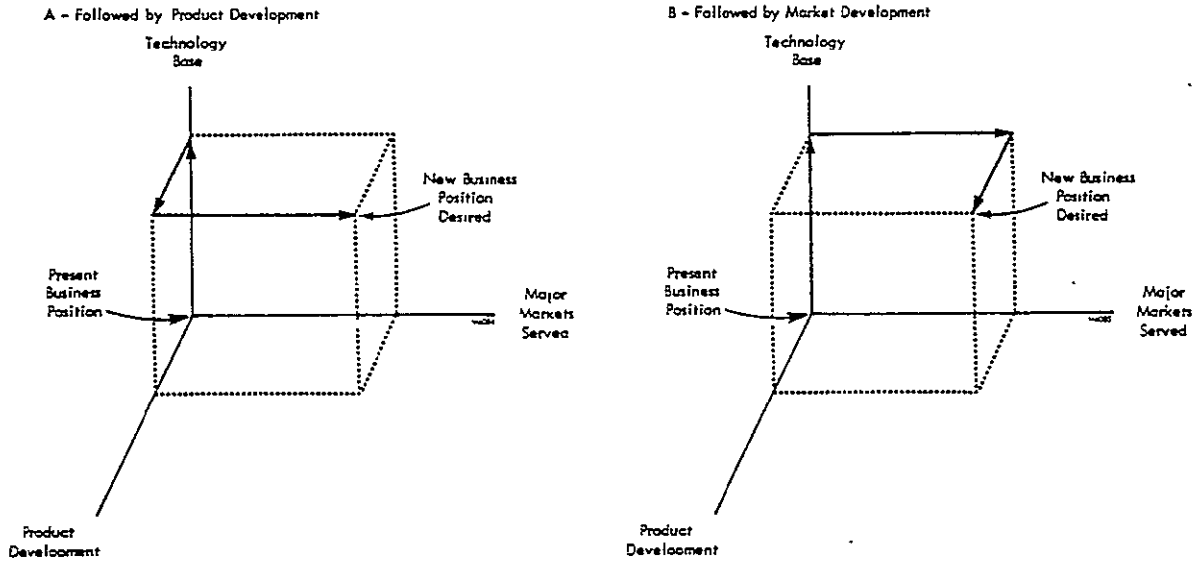


FIGURE 3.16
SERIES ROUTE - PRODUCT DRIVEN

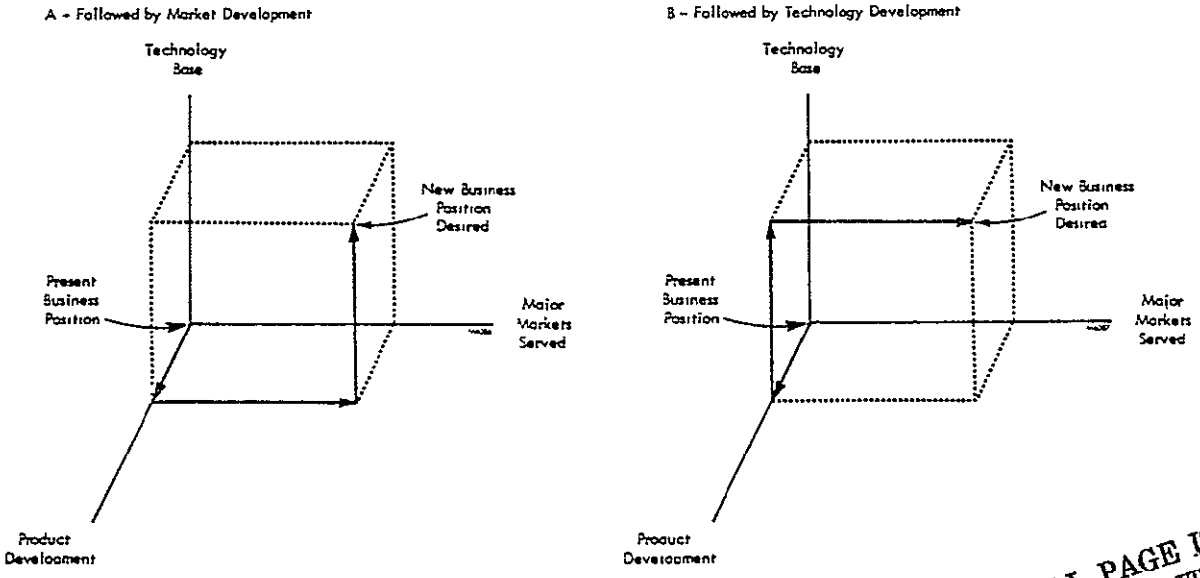
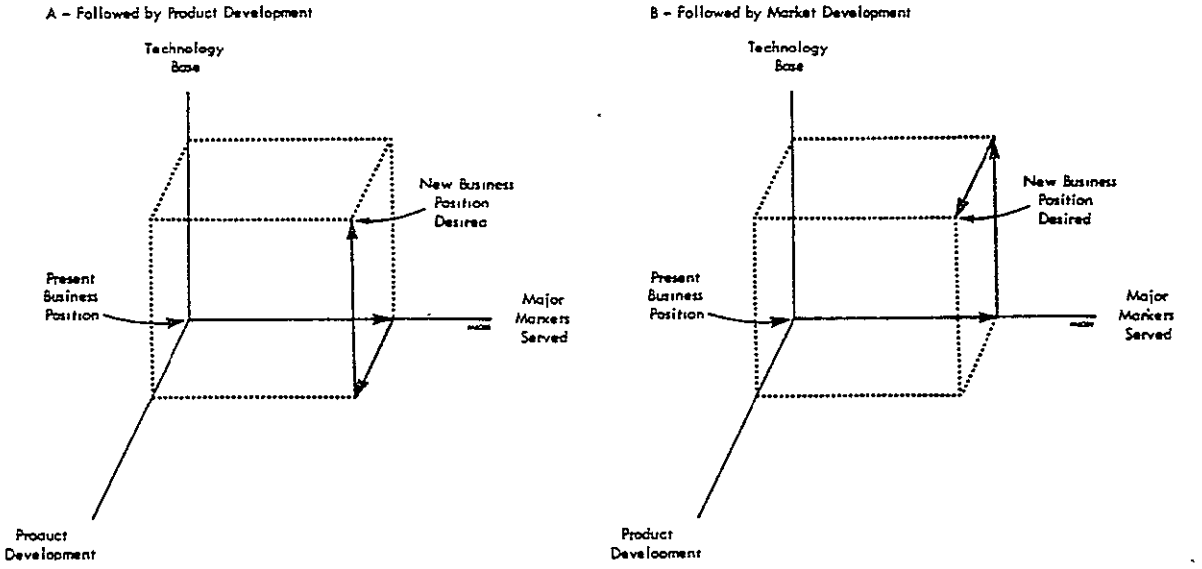


FIGURE 3.17
SERIES ROUTE - MARKET DRIVEN



TECHNOLOGY DEVELOPMENT AFTER PRODUCT AND/OR MARKET DEVELOPMENT RESTRICTS REWARDS The series development routes demonstrated in Figures 3.16 and 3.17, while they do exist within the context of the concepts presented in this report, do not typically occur in industry. The development of a technology after product or market development restricts the rewards to be gained. If a technology development is required, then it should occur before product and market development efforts to maximize the return. The technology development is the foundation of the change in a company's business position.

SERIES ROUTE REDUCES RISK BUT LENGTHENS REQUIRED TIME The series development of first technology, and then products, followed by markets reduces the risk significantly over the direct route. The drain on the company's resources at any given moment is also less severe. Additionally, it allows for significant positive feedback to influence the development route being pursued. The disadvantage of this route, however, is that it requires a tremendously long developmental time. By pursuing each major aspect in a serial fashion, the opportune times for product announcement and penetration of new markets may be bypassed. The company also risks their particular technology being obsoleted before it is even introduced into the new market area.

FLEXIBILITY AVAILABLE Another advantage of the series approach is that the sequence can be stopped at any moment and other options pursued. It offers significant flexibility, especially in areas where a company is not extremely confident of the market details.

COMBINED DEVELOPMENT ROUTE

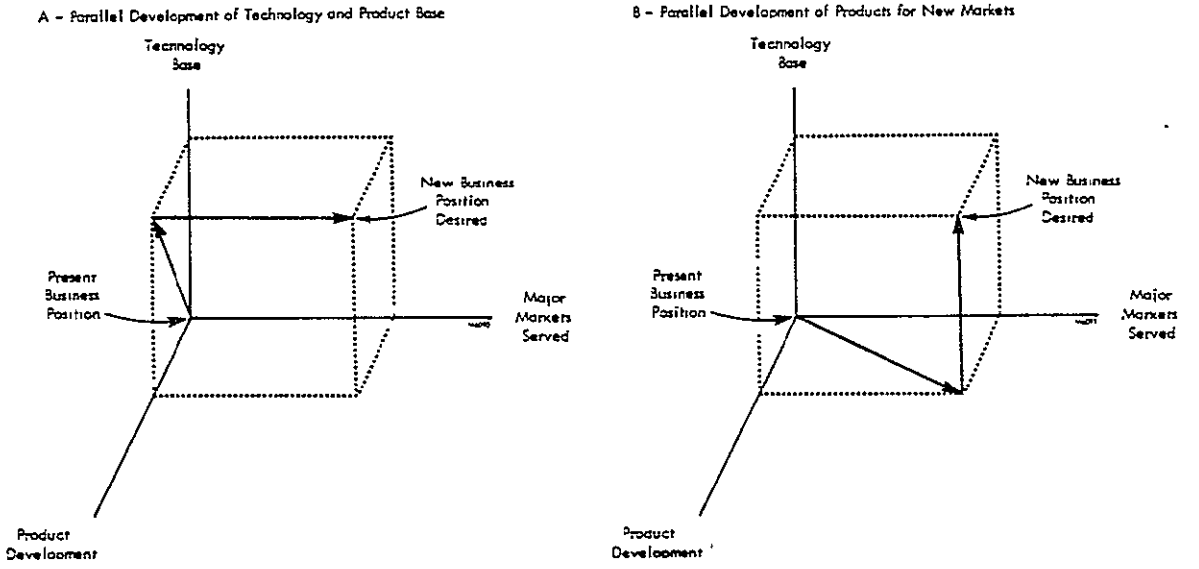
There also exists an infinite number of combinations of the direct and series development routes that can be segregated into two categories:

- Parallel series development routes
- Series parallel development routes

OPTIONS IN PARALLEL SERIES ROUTE The most common approach used in the parallel series route is that shown in Figure 3.18a, in which the technology base and appropriate products are developed simultaneously first and then introduced into new markets. This is very common within the semiconductor industry. An alternative, but less optimum, approach is shown in Figure 3.18b, in which new products and markets are developed based on the old technology base. Upon finding that penetration of those markets is not sufficient, a new technology base will be introduced to enhance the product performance characteristics. If this is not followed by further product development, then the investment in technology will be extremely limited.

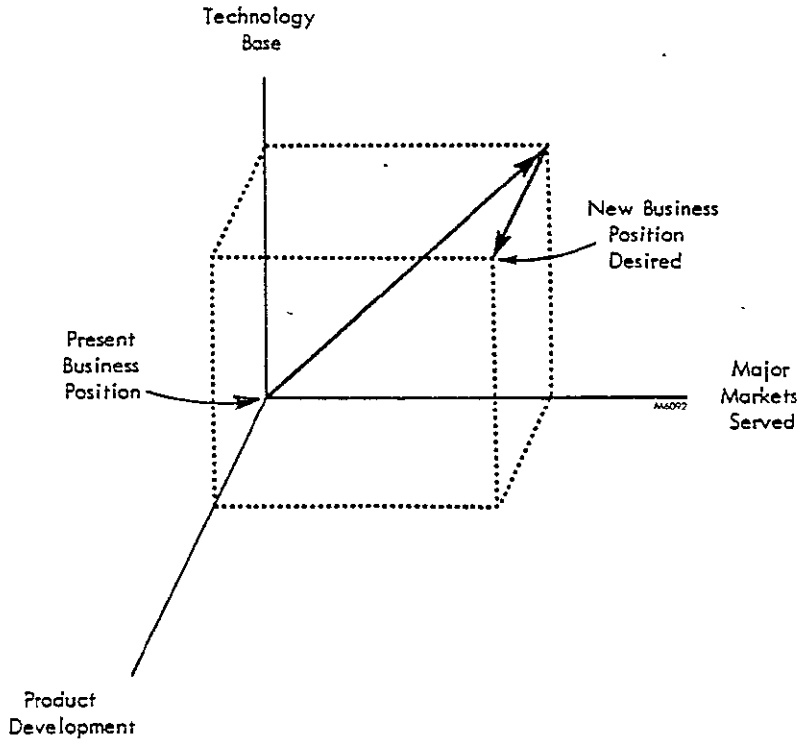
FIGURE 3.18

PARALLEL SERIES ROUTE - MOST COMMON APPROACHES



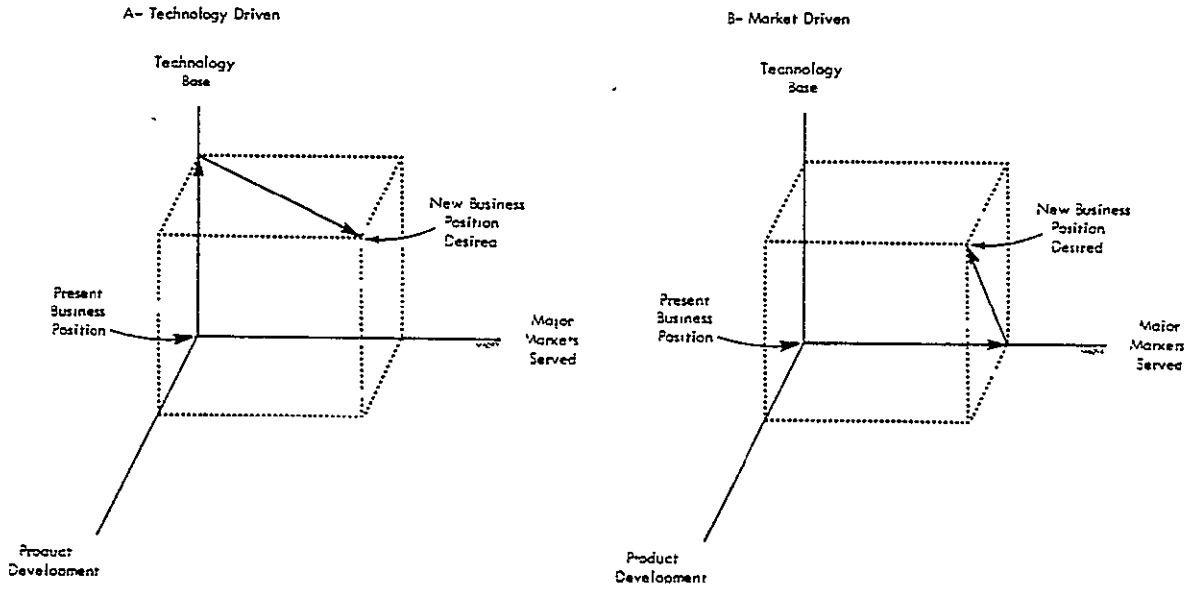
There is a third alternative. It is, however, an unlikely route to be taken by any company. It is demonstrated in Figure 3.19, in which new markets and technology bases are developed simultaneously and then new products are developed to increase penetration of markets. Previous discussions in the technology base section concerning the development of the technology base and new markets in series or simultaneous fashion concluded that such an approach was not meaningful. Since it forms the foundation of this route, it is improbable that such a route would ever be pursued, especially if all risks are to be assumed by the company alone.

FIGURE 3.19
PARALLEL SERIES ROUTE - IMPROBABLE APPROACH



OPTIONS IN SERIES PARALLEL ROUTE The series parallel development route is similar to the parallel series development route. The emphasis, however, shifts from what is the foundation of the development route. The series parallel development route is based upon the development of only one business aspect prior to the simultaneous development of the other two aspects. The two most common approaches to the series parallel route are demonstrated in Figures 3.20a and 3.20b.

FIGURE 3.20
SERIES PARALLEL ROUTE



LARGE CORPORATIONS PURSUE DIFFERENT ROUTE FROM SMALL COMPANIES It is not uncommon in large corporations to have a separate technology R&D facility. From the investigations in the research and development areas, many new technologies are developed virtually independent of any intended product or future markets. Then, through operating business units within a corporation, this new technology is applied to opportunities in new markets requiring new products. This approach is shown graphically in Figure 3.20a.

This usually typifies the larger companies within an industrial area. The smaller companies usually pursue the parallel series route of developing products and technology simultaneously and then approach new markets with the resulting products. The large corporations will also, but in addition they have the financial resources available to allow them to pursue first the independent development of various technologies and then the parallel development of both new product and markets.

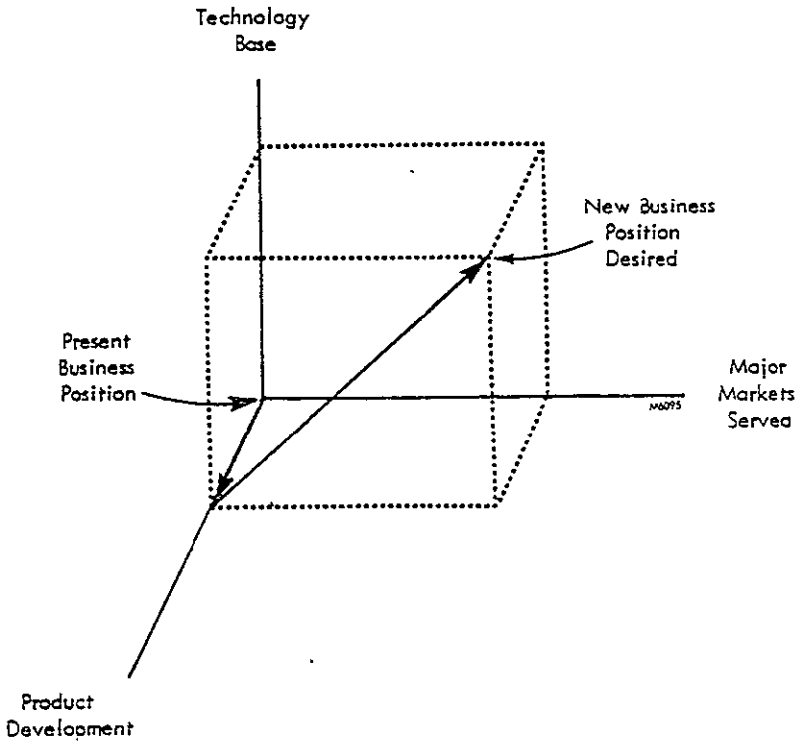
TECHNOLOGY DEVELOPMENT MOST LIKELY INDEPENDENT OR ASSOCIATED WITH PRODUCT DEVELOPMENT Many companies introduce their basic product lines into new markets. Penetration of those new markets, however, may be found to be restricted due to the limitations of either the technology or the product. Consequently, the firms will begin the pursuit of a parallel activity in which products and technologies are developed simultaneously to enhance the penetration. This is typified by the approach shown in Figure 3.20b.

There is a third alternative in the series parallel route, as shown in Figure 3.21, in which products are developed for presently served markets using established technologies. Then through a parallel effort, new markets and technologies are developed. The drawback to this particular approach is that it does contain the element of a simultaneous development of technology and markets which, in the previous sections discussing technology base, has been downplayed as a viable option. There is no true advantage to either the supplier or the end-user in seeking a new market and technology base development simultaneously. Thus when a technology development is occurring, it is more likely to be either on an independent basis or associated with the simultaneous development of products, not the simultaneous development of new markets.

RISKS CAN BE REDUCED BY ACQUISITION AND/OR GOVERNMENT ACTIONS Risk can be reduced in the combined development routes through a series of small acquisitions and/or government fundings. The parallel pursuit of two of the major business aspects can be handled by most companies. However, the simultaneous development of all three major aspects is very seldom pursued.

Through government actions, if the risk can be reduced in one of the three major aspects, then a company may accelerate its arrival at the new business position. Combining government actions and a series of small acquisitions can accelerate the arrival at the new position even faster. The use of the acquisition route assumes, however, that there are established companies already in existence and that some form of the products needed already exists.

FIGURE 3.21
SERIES PARALLEL ROUTE - PRODUCT DRIVEN



DEVELOPMENT OF PHOTOVOLTAIC VENTURES

There will be many and varied approaches to the photovoltaic venture, depending upon company resources, their assets, and their relationships with both the government and their competitors. Which of the discussed routes will become the dominant is not clear at this point.

TECHNOLOGY FORMED BASIS FOR VENTURE Historically, photovoltaic ventures have evolved from companies that have some technological foundation related to the solar cell device itself. The development and ultimate application of these technologies to viable commercial products has either been pursued internally or sold/licensed to other companies which have proceeded with the development of the commercial products.

In all cases, activities have been on a relatively low scale basis. The newly formed companies have usually been underfinanced and typically small, having relatively little production capacity. Those companies that have continued to pursue the development of the photovoltaic ventures internally have not made it a major portion of their overall business. These investments are continually growing, however, and are intended ultimately to represent a significant part of the company's business activities.

INDEPENDENT COMPANIES GENERALLY ACQUIRED BY LARGE CORPORATIONS

For the newly formed small photovoltaic companies, they have virtually all been acquired by large corporations. The two basic reasons for this are:

- The newly formed companies find they are underfinanced and cannot afford the developmental costs of technology, products, and new markets.

- The larger corporations envision the photovoltaic venture as a long-term, high-growth opportunity and are motivated to invest in such future potentials. They realize they do not have internally the technological or product base with which to gain a foothold in the new markets. To accelerate their development in this particular marketplace, they choose the acquisition route over the internal development route.

BASIC CONFLICT BETWEEN GOVERNMENT AND INDUSTRY OBJECTIVES

There is a basic conflict between the goals and objectives of the federal government in the photovoltaic venture and those of private enterprise. The federal government is in the pursuit of resolving a potential energy crisis problem. Private industry, however, is interested in the photovoltaic venture only from a financial viewpoint. They are responsible to their stockholders and must return a reasonable profit on any investment. The motivation to resolve a national energy crisis is not yet a formidable part of any corporation's plans or objectives.

The federal goals and objectives do not necessarily consider profit making as a significant element. It is implied on the part of the federal government that profits will be forthcoming, but it has not been used as a guiding force in developing the photovoltaic venture, certainly not in the same perspective as industry views it.

It is unlikely that private industry will change their basic goals and objectives to make them compatible with those of the federal government. Consequently, the responsibility for making the federal government's goals and objectives compatible with those of private industry lies squarely with the federal government. Through their actions, policies, and programs, they must account for all of the restrictions that private industry is bound by and find a constructive means by which the national goals and objectives can also be accomplished.

3.4 CLASSIFICATION OF COMPANIES

CLASSIFICATION OPTIONS

NEED TO CLASSIFY

The approaches to developing a new business position are varied in nature, size, and the route pursued. To arrive at some common denominators such as perceived barriers to investments, basic elements of the investment process, and items influencing the final investment decision, there is a need to classify companies in a meaningful order.

One of the most common methods of classifying companies is to segregate them by their industry type. Examples of this would be petroleum-based, chemical-based, material, industrial, and semiconductor companies. Within each of these industry-type classifications, the companies can be subgrouped still further by their annual dollar volume of business and assets. Other schemes of classifying these industrial types would include segregating them by the markets served, or by the type of structure that the company represents; i.e., a narrow-based company serving relatively few markets, or structured in the form of a conglomerate in which there are many companies serving many market areas. Still other classification schemes could be based upon their technology base, or their type of products.

In all of these cases, very little insight is obtained as to what the investment processes are; namely, how a final decision is made concerning an investment; how risk is handled; or what the perceived barriers may be to an investment, especially in a high-risk area such as the photovoltaics venture. Thus there is a need for a classification scheme that brings to the forefront the motivations why a company would invest in a high-risk operation.

CLASSIFICATION METHOD

In addition to motivation as being a method of classifying companies, a second perspective is based upon the company's relationship to the photovoltaic venture; i.e., its relationship to the technologies involved, the products and the markets to be served. Combining this scheme with that of motivations will give greater insights into how a company may view the ramifications of such an investment.

FOUR COMPANY GROUPINGS IN RELATION TO PHOTOVOLTAIC VENTURE

The concept of classifying companies as to their relationship to the photovoltaic venture and their motivation for making the investment is shown in Table 3.3. The photovoltaic industry can be looked upon as one that supplies electrical generating equipment. Thus the first classification of companies that would be identified are:

- Suppliers of energy-generating equipment
- Suppliers of materials that would allow for the generation of electrical energy
- Related peripheral equipment companies

These companies will be influenced by a significant photovoltaic industry development program. Their markets will especially be influenced in a direct fashion.

TABLE 3.3
COMPANY GROUPINGS BY INVESTMENT MOTIVATION

Company Groups	Investment Motivation	
	Major	Minor
Energy Market Companies		
Consumable producers	Protect market position through diversification in energy business	Enhance image
Energy-generating equipment manufacturers	Long-term ROI	Short/intermediate-term ROI
Related equipment manufacturers		
Large Energy Users		
Functional systems supplier	Protect/develop supply source	ROI
Related Technology Companies		
Semiconductor-based companies	Major business spin-off	Diversification
Materials-oriented firms	High growth, near-long-term ROI	Image
	Industry technology leader	
Unrelated Companies		
Conglomerates	High growth, good ROI	Image
	Diversification	Long-range position
	Enhance other markets	

Another category of companies that relate to the energy aspect are those firms that are involved in the consumption of the electric energy that is generated. In particular, reference is being made here to large energy users who may require a captive source of electrical energy.

These two categories of companies thus cover the market and the product aspect of a photovoltaic business position.

A third category of companies that would be involved or interested in photovoltaic industry developments would be those that have a compatible or related technology base. This would not only include a technology in the solar cell device area, but also technologies in the generation and production of the basic raw materials that may be consumed in or part of photovoltaic products. This type of company covers the third aspect of the photovoltaic business position, namely the technology base.

A fourth type of company classification also exists. This would be the company that has no relationship at the present time to the photovoltaic industry or the energy-producing industry. There exist such companies that will be motivated to enter this particular potential high-growth industry as a result of an internal diversification objective.

MAJOR AND MINOR MOTIVATIONS The motivation for any of these types of companies to invest in the photovoltaic venture can be broken into major and minor groupings. An investment in the photovoltaic industry will always be driven by one or more major motivations. At the same time, there may be several minor motivations that would also encourage a company to make the investment. However, these by themselves would not be of sufficient magnitude to cause a company to make the necessary investments. These minor motivations serve to round out the total package for justifying the entrance into a high-risk photovoltaic venture.

TYPES OF COMPANIES AND THEIR MOTIVATION TO INVEST

ENERGY EQUIPMENT AND PRODUCTION COMPANIES

This group of companies includes those that produce energy consumables, such as gas, fuel oil, coal, and/or uranium. It also includes that group of companies that produce energy-generating equipment, such as hydro, steam, or gas turbo electric generators. Other related equipment manufacturers would include companies supplying such items as power regulators, coal extraction equipment, and oil-drilling equipment.

MAJOR MOTIVATIONS The major investment motivation of this group of companies is one of protecting their long-range market position through diversification in the energy business. The major petroleum-based companies, as an example, recognize that oil supplies will ultimately decrease. Unless they have positioned themselves in the business of supplying alternate energy sources, their future business will also decrease. This would include diversification into such items as geothermal equipment, coal and uranium production, and photovoltaics. The same statement is equally true for major electric generating equipment companies such as Westinghouse and General Electric, both of which have already diversified from steam turbine into gas and nuclear power systems and have photovoltaic programs in existence.

A second major investment motivation for these companies would be long-term return on investments. If there were no prospect for acceptable long-term return through diversification in the energy business itself, then they would have to look outside of the energy business for future investments. However, at the present time there appears to be no end to the increasing demand for energy. Consequently, prospects for excellent returns in the energy field are possible.

MINOR MOTIVATIONS A minor investment motivation would be the potential to enhance the company's image in the public's eye by showing interest in photovoltaics. This may, however, be impossible to accomplish. It is possible that the public would be opposed to large energy companies diversifying into other energy areas. Still another minor investment motivation could be the development of short- or intermediate-term return on investments. This would be possible, depending upon the rate of market development and the specific government policies and actions that are implemented.

DIRECT ENERGY PRODUCERS AND LARGE ENERGY USERS

It is possible that direct energy producers or large functional system suppliers that require independent power sources might invest in photovoltaic production facilities with the major investment motivation being to protect, ensure, or develop a source of supply of photovoltaic arrays. This implies to some extent that the normal supplier sources are not expected to develop rapidly enough to meet the market demand.

The photovoltaic products in these cases would be very specialized in nature for such intended uses as cathodic protection of pipelines, power for remote microwave transmitters, or production of power at central or substation locations within electrical utility districts. Another example might be the major water pump manufacturers wanting to ensure a supply of photovoltaic power sources at

the lowest possible prices for the irrigation industry. A second and probably minor investment motivation for this company group would be the obtaining of a reasonable return on investment for their efforts at photovoltaic production.

RELATED-TECHNOLOGY COMPANIES

The related-technology companies not only include those companies with a technology base capable of producing solar cell devices, but also those companies that are producers or suppliers of raw material involved in the production of photovoltaic products. Examples of the companies in the related technology grouping would include the semiconductor companies, and manufacturers of plastics, films, silicon, polysilicon, glass, and aluminum.

MAJOR MOTIVATIONS For this group of companies, the major investment motivation would be to form a new business venture through a spin-off of their technology base or material production expertise. As a general rule, these companies would be looking for high-growth markets in their new investment. Excellent near- and long-term return on investment would also be a major requirement.

It should be noted that the near-term return on investment will be just as important to these companies as the long-term return on investment. This is a clear distinction of this company grouping as compared to the energy-producer and equipment company categories.

A third major investment motivation would be the desire to use their expertise in technology or material manufacturing capabilities to become an industry technological leader.

MINOR MOTIVATIONS Minor investment motivations would include the desire for diversification of their overall product and customer base. In addition, the image of a company moving into advanced technological energy supply areas would be of some value. In general, the public would not view these companies in a negative fashion as they may view petroleum-based companies entering the photovoltaic industry.

UNRELATED COMPANIES

The unrelated companies that might possibly invest in a photovoltaic venture are those companies with no current relationship to photovoltaics by virtue of their technology base, material expertise, or involvement in the energy markets. Should such companies decide to invest in photovoltaics, their major motivation would be based upon the perception that the photovoltaic industry offered high growth potentials with extremely good potential for excellent-, near-, and long-term return on investments.

Secondly, they would also consider it as a significant diversification within their company. To some extent, this motivation factor would imply that these companies tend to be conglomerates which are already accustomed to the diversification process.

In certain instances for the unrelated company groupings, a major investment motivation may also be to enhance its other markets that it presently serves. An example here would be a battery company diversifying into photovoltaics because they believe it would enhance their battery markets.

With respect to minor investment motivation, all of these unrelated companies would consider image in the new photovoltaic energy area to be of interest. A second minor motivation would be that many of these companies would perceive their venture in photovoltaics as giving them the possibility of an excellent long-range position in a new high-growth industry.

3.5 SPECTRUM OF DECISION METHODS AND RELATED INFLUENCES

INVESTMENT PROPOSAL PROCESSES

OVERVIEW

Before a company can arrive at a decision to invest in photovoltaics or any other venture, there must be a proposal set forth that suggests that an investment be made. Some source and mechanism for bringing this proposed investment to the attention of the corporate decision makers must exist within the company.

FOUR BASIC INVESTMENT PROPOSAL SOURCES There are four basic sources that can generate an investment proposal and carry it forward to the attention of the appropriate individuals.

The major sources for investment proposals include:

- The business unit
- A corporate executive
- The corporate research and development group
- Venture analysis group

Within a given company, any one or a combination of these investment proposal avenues may exist. In addition, there may be specialized methods by which investment proposals are also generated within those companies.

MECHANISTIC ASPECTS ONLY COMMONALITY BETWEEN COMPANIES It should be noted that any of these approaches within a given company will differ from its counterpart in some other company, even within the same industrial classification of companies or any other classification that may be applied. In effect, each company tailors the basic investment proposal procedures and builds into them those items they wish to accentuate.

Most of the investment proposal processes in the companies surveyed were, however, very similar to one another from a mechanistic point of view; i.e., most all of them were based on a business plan for the development of a given project. Discounted cash flow analyses, return on investment, payback periods, and other financial parameters were typically used to place all business plans on a comparable basis. In addition, some companies carried this analytical analysis a step further by analyzing the sensitivity of financial returns to market inputs and investment requirements. Still other companies went one further step in sophistication to consider potential investments with respect to expected market share, relative market share, capital intensity, and other factors.

There are no particularly distinguishing characteristics regarding investment processes from a mechanistic standpoint from company to company. The differences rise primarily in the area of details in the aspects of primary emphasis.

BUSINESS UNIT UP PROCESS

The most common approach to development of a new business venture is from the grass roots level, especially in a major organization. The idea germinates within a division at a relatively low level and builds slowly, ultimately becoming a line item in the division's overall business plan. It does not become visible to the corporate executive level until it has reached a size that requires an investment above a predetermined level, depending upon how the product and the potential liability to the organization has been defined.

By this time, the investment has received the adamant support of at least one or more "champions." Such a "champion" will carry the bulk of the effort in seeing that all of the necessary requirements for a corporate review are met. In most cases, this individual is one who is known and creditable to the executive staff of the company.

The new proposed venture also generally will fit within a particular market interest of the supporting division and will have at least a long-term potential for excellent return on investment. In addition, the proposed idea will generally fit the accustomed manner of marketing and distribution of the other divisional products. There are exceptions to this where the company has strong diversification tendencies and divisions are given wide latitudes. This is not, however, the general case.

The requirements for bringing the investment proposal to the attention of the corporate staff is well known by both the division leaders and the "champion." These requirements would include the preparation of a business plan, the analytical analysis of several key financial parameters that are of high interest to the corporate staff, a discussion or preparation of papers covering the long-range and short-term potentials of the investment. Additional detailed reports may be necessary to support or justify the potential venture. It may be that a separate division is required because of the peculiar characteristics of the proposed investment.

In most cases, the corporate staff will not request additional information beyond that supplied. If sufficient information is not supplied by the supporting organization, then the executive staff may come to a negative decision concerning the investment. It must be emphasized that the impetus for supplying all of the needed information is on the shoulders of the operating division and "champion."

C-2

CORPORATE EXECUTIVE DOWN PROCESS

Occasionally the corporate executive level will strategize that the company should move into another investment area. The suggestion for an investment may come from a single individual within the corporate staff or from a group of individuals who feel such investments should at least be investigated.

Often the decision process in this case is not based upon nearly the large amount of quantitative data that would ordinarily be used should a division submit a new investment consideration to the executive staff. Upon receipt of a suggested investment area, the appropriate division will generate an implementation plan and resubmit it to the executive staff for approval. In many of these cases, approval of the basic concept has probably already been implied and it now becomes a matter of approving the tactical details. In effect, the "champion" is a decision maker at a corporate level and by his nature will not require as sophisticated a justification as he might otherwise require on an investment in which he is not as familiar or emotionally involved.

The investment proposal process within the supporting division is essentially the same as described in the business unit up process, except that less detail is usually needed and a quicker decision can be arrived at due to the prior interest on the part of the corporate staff. If, however, the corporate staff member who suggested the investment proposal originally is not a dominant member of the corporate decision group, the proposal may require the same depth of analysis as would otherwise be required.

CORPORATE R&D GROUP PROCESS

Another source of investment proposals is the corporate research and development (R&D) group. A major function of many corporate R&D groups is to stay abreast of the technologies affecting their company's basic business, including developing technologies that may represent reasonably allied future diversification programs. In most cases, the R&D group in following and developing technologies attempts to transfer the technology to an operating divisional group at the earliest possible time. This is done because the divisions truly have greater resources for implementing the new technologies, particularly in the business and marketing area. Even in the cases where the technology is not directly related to a division's products, the R&D group will attempt to place the technology in the most appropriate division. Once the technology base has been successfully transferred to a division, the investment proposal process follows the business unit up procedures.

Should placing the technology within a divisional group fail, the other alternative may be to promote the commercial development of the technology at the executive level. This approach is seldom used because it quite often fails. A divisional "champion" is needed, and if the R&D group has not made a convincing case for profitable new business development at the divisional level, it is unlikely that they will be able to develop a sympathetic audience at the corporate executive level.

VENTURE ANALYSIS GROUP PROCESS

Within many companies there exists a specialized group known as the venture analysis group. The objective of this group is to investigate programs that might lead to the continued investment of company resources into high-growth opportunities. This group will pursue and analyze proposed concepts for investments from many sources. They would include sources within the group, from the R&D organizations, from the various business units, the corporate staff, and from sources outside the company also.

Where such organizations exist, all proposed invesments, regardless of source, will be funneled through this venture analysis group. This group will be especially equipped to supply all of the needed information for the executive staff at the time a decision must be made. The actual work in the preparation of the reports may ultimately have to be supplied by the supporting division or the R&D group, but it will be under the direction of this venture analysis group and special assistance will be made available.

The processes and procedures carried out by the venture analysis group do not differ in substance from those required of a business unit up proposal process. The advantage of a company having a venture analysis group is that more opportunities can be investigated, coordinated, and ranked.

Often within a given fiscal year, several hundred investment opportunities may be made available. It would be one of the prime functions of a venture analysis group to rank these opportunities in such a fashion that the corporate staff will have to make decisions on relatively few opportunities, namely those that will have the greatest benefit to the long- and short-term objectives of the company.

The existence of a venture analysis group is usually associated with companies that have large revenue bases that generate significant profits and positive cash flow conditions. In addition, those companies that are heavily involved in long-range strategic planning also tend to have a venture analysis group available within

the corporation. To maintain excellent profits, high cash flow, and assure long-term strategic planning is developed, companies have found it necessary to establish such venture analysis groups that are dedicated to those specific purposes.

ELEMENTS OF THE INVESTMENT PROPOSAL PROCESSES

There are several elements that can be identified as being common to all of these investment proposal processes. These would include:

- A need to develop a "champion" within a given company. It is the "champion's" responsibility to gather all of the required documents, justifications, and ensure that the necessary statistical data is made available. The more reputable the "champion" is, the more likely the investment will be looked upon in a favorable fashion at the time of final decision.

- A need for statistical data on various aspects of the investment. In this area, the statistical data applies to the nonfinancial issues, namely the aspects involved with market growth potential, price elasticity within the market, product descriptions, resources available within the company, and resources that must be acquired if the investment is to proceed forward.

- A need to perform certain minimum analyses of financial parameters. These also will vary from company to company, but in general the calculations concerning total investment requirement, a discounted cash flow analysis, a return on assets or return on investment, are usually the minimum items that are required.

- A need to find a compatible operating division within the company to support the proposed investment. This is especially true during the early stages of the venture development. Very few companies will form a new division early in the investment cycle.

- A need to identify the priorities and the major motivations that will enhance a company's likelihood to make the proposed investment. The proposed investment must enhance these motivations and be compatible with company objectives.

ELEMENTS OF FINAL DECISION ENVIRONMENT

OVERVIEW

Once all of the necessary requirements of the investment proposal process are met, there still needs to be a final decision made by the corporate staff before an investment in a high-risk venture can be finalized. The involvement of the corporate executives responsible for the final investment decision adds a new element into the investment picture. In many cases, these individuals will not be as knowledgeable of the proposed investment as the "champion" or supporting division. The "champion" and the supporting division thus have the responsibility to sell the corporate decision-makers on the ideas and concepts of the proposed investment.

The final decision process is a critical element in the overall investment environment. The interaction of the final decision authority and the supporting "champion" of the proposed investment, along with the influence of all of the statistical and analytical parameters come to play in the final decision environment. Through a review of the interaction of these elements, insights into the relative importance of all of these elements can be obtained.

FINAL AUTHORITY

There exist within each company a final authority that can determine if an investment will be made or if the nature of the investment will be changed. The existence of this final authority is for the purpose of supporting or denying investments in high-risk ventures.

GROUP SIZE VARIES This final authority will vary in size from one to several persons. There will exist within this final authority group a dominant individual who will have significant influence upon the ultimate thinking of the entire group. Each member of the group, however, will have a role to play in the final investment decision. Their role may vary from simply being a passive observer with occasional questioning for clarification of issues to being a "devil's advocate." These persons will not only interact with the "champion," but also with each member of the final authority group. Their group purpose will be to bring out all issues and to resolve them in as appropriate a manner as possible prior to making a final decision.

ONE-PERSON AUTHORITY In the case of a one-person final decision group, this individual is usually a high-ranking official of the company. Typically, small companies are dominated by a single ultimate decision-maker, but even large corporations can also be dominated by such an individual. This ultimate decision-maker in effect is a dictator within the investment environment. This individual usually had a significant influence upon the original establishment of the company and has had a dominant role in the development of the company since its origination.

TRIARCHY APPROACH There also exist larger ultimate decision-making groups. For instance, there exists a triarchy or three-member ultimate decision group. However, within this triarchy there is always one dominant member. While the two remaining members have significant influence upon the ultimate decision, their role is still supplemental to the dominant figure within the group. The dominant individual within the group may be the president of the company and the other two members key individuals within his organization, such as the Vice President of Operations and the Vice President of Finance.

MULTIMEMBER GROUP DOMINATED BY SMALL SUBGROUP Still larger multimember groups may make up the ultimate decision-makers. Again, there will always be a dominant member within this group. These larger multimember groups will vary in size from five to ten members. As the size of the multimember group increases, there is always a tendency for a select group of individuals within the total group to evolve as the dominant members of that group; and within that subgroup there will be a dominant individual.

The size of the multimember group can increase to as many as 20 to 25 members in certain organizations. However, within such large groups there will be a subgroup of three to five members that will dominate.

For the smaller groups in the range of three to seven members, the dominant individual can and often does make the ultimate decision. The lesser dominant members of these groups may or may not express their viewpoints of the investment until they have sought out the viewpoint of the single dominant individual in the group. How that group operates depends upon tradition and the political status they hold within the company. The dominant individual within the group may seek out the viewpoint of each individual member. However, he has the power to completely overrule the thinking of the majority.

GROUP SIZE NOT RELATED TO COMPANY SIZE The survey of companies indicated that the size of the final decision-making group is not related in any fashion to the size of the company nor to the company assets. The size of the final decision group seems to

depend upon an evolutionary process. As long as the original founders are in a controlling position of a company, the size of the final decision group tends to be small. As the original founders are replaced within the organization, there is a tendency for the decision group to become larger and larger. The development of the subgroup within a large multimember group is usually made up of the more dominant members of the corporate staff who have achieved above-average political stature within the corporate structure.

COMPONENTS INFLUENCING FINAL AUTHORITY

The final authority group makes no decisions unless requested. There must be some outside influence forcing the group to make a decision concerning an investment. Even in the case where an investment suggestion or strategy is put forth by a member of the final decision-making group, it must be sent downstream within the corporation and resubmitted through normal channels with all of the supporting information.

There are three main elements that come to play during the final decision process that will influence the decision of the group. These influences include:

- The "champion." Such a "champion" must exist regardless of the company size or structure and must usually be in addition to any "champion" that may exist within the ultimate decision-making group. The strength and stature of an active "champion" of the proposed investment is critical and will have a significant influence upon the final decision.

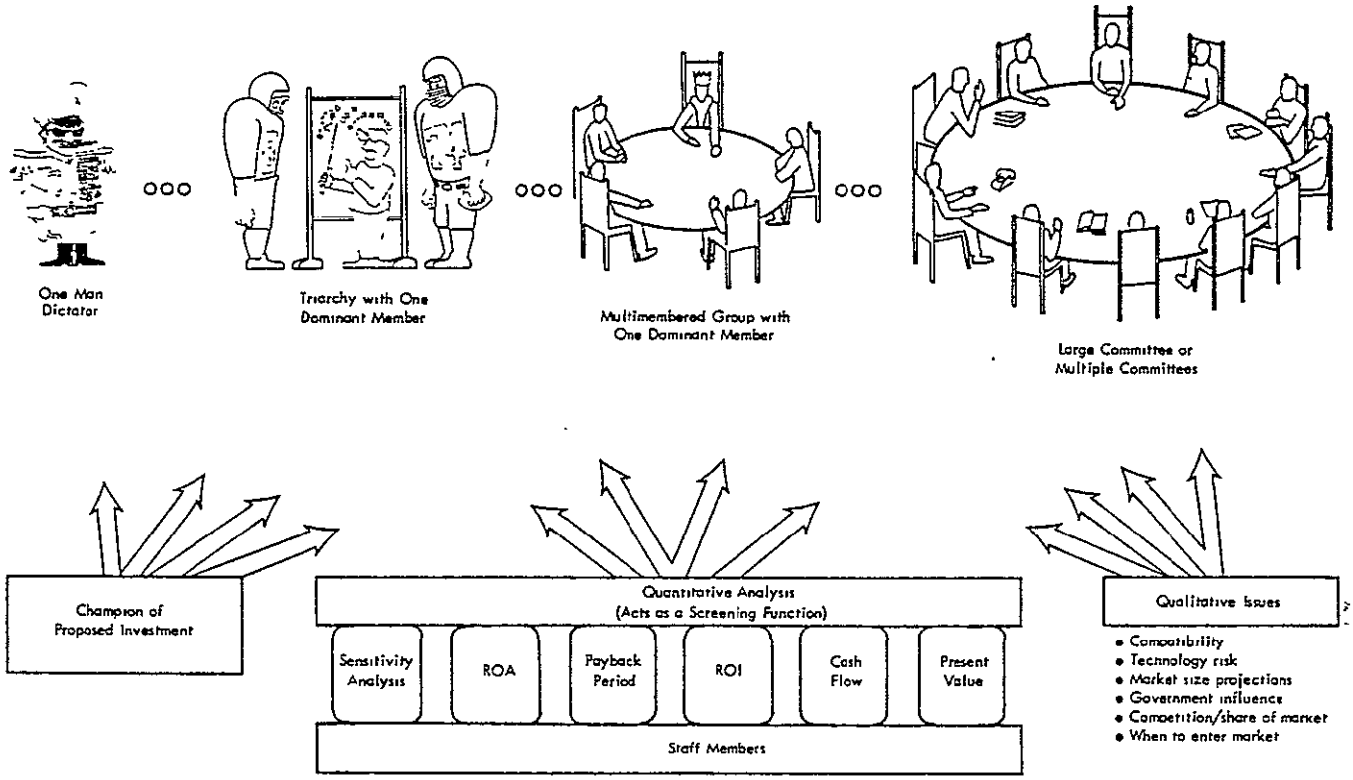
- The results of quantitative analysis. These analyses are based primarily upon financial parameters, such as the return on investment, return on assets, discounted cash flow, present value of investments, payback period, and many other sensitivity analyses as may be determined by the ultimate decision-makers.

- The relative knowledge and opinion on qualitative issues by both the "champion" and the final authority group. Qualitative issues include such items as technology risk evaluations, market size projections, government influences, competition and share of market potential, proper timing to enter the market, and compatibility with corporate objectives.

These influences, along with the spectrum of group size of the ultimate decision-makers, are portrayed in Figure 3.22.

FIGURE 3.22

SPECTRUM OF ULTIMATE DECISION-MAKERS AND INFLUENCES AT PLAY



ROLE OF "CHAMPION" IN DECISION MAKING

No proposed idea will attract investment money unless there is a strong, well-respected individual or "champion" within the organization to push for investment consideration. This is true regardless of company size and complexity.

The role of the "champion" is to be the spokesman for the investment concept. It is the "champion's" function to gather together all of the necessary information and to see that it is presented in its most favorable light to influence a positive decision in the investment environment. While the "champion" may not do all of the actual work, it is still that person's responsibility to see that the necessary elements are brought together in the proper form to influence the decision.

"CHAMPION" IMAGE IS IMPORTANT The "champion's" personal relationship with the final authority may be the overlying influence in the entire decision process. A "champion" with a weak background or a tendency to be overoptimistic will cause the group to discount much of the quantitative information. Conversely, if a "champion" has an excellent reputation and political stature within the company, quite often the quantitative information may be regarded in a more favorable light than would otherwise.

The influence of the "champion" will also have a significant effect upon how the qualitative issues are viewed. Qualitative issues are always associated with judgments and opinions. A strong "champion" can positively influence the position of each decision-maker in regard to marginal qualitative issues. Conversely, a weak "champion" may not be able to counter some of the more significant qualitative issues and will therefore be dominated by the final decision group.

ROLE OF QUANTITATIVE ANALYSIS IN DECISION-MAKING

The quantitative analysis covers the analytical aspects of the venture description. It covers all of the items that can be quantitatively described and presented in standard format. This usually is centered around the financial aspects of the investment. It will be part of the overall business plan, which shows how the new venture is to be implemented and its various phases of development.

From company to company, the details will vary, but it may also include a proposed description of the facilities, such as size and location, and the staffing requirements on an annual basis. As a minimum, it will cover the required invesment on an annual basis, expected revenues, discounted cash flow analysis, standardized return on investment or return on assets analysis, and some sensitivity analysis relating to various market penetration scenarios.

ANALYSIS REQUIREMENT DEPENDS ON INVESTMENT AND GROUP SIZE The degree of quantitative analysis usually increases as the size of the requested investment increases, since the risk also increases significantly. The larger the investment requested, the more analysis is devoted toward sensitivity analysis to determine what the truly key elements are that will affect the end result of the investment.

To a certain extent, the quantity of analytical analysis required will also increase as the number of members in the final decision group increases. This is based on the fact that as the size of the group increases, there is a tendency for various members to specialize in certain areas. As a result, they will ask pertinent

questions in their area of expertise that may not be asked if the group were of a smaller size. Consequently, the supporting division and "champion" of the proposed idea must be prepared to answer a large variety of questions and to support them with as much analytical analysis as possible.

ANALYSIS USED TO RANK ALTERNATIVES A very important note to be made is that the quantitative analysis is generally used as a screening procedure rather than a decision procedure. A proposed venture analysis will not be eliminated from consideration because of the results of the analytical analysis. Many proposed investments do not meet the minimum requirements of a company for making an investment. However, due to the strong capabilities of the "champion" or certain overriding nonanalytical issues, an investment proposal will still be brought to the attention of the corporate decision staff for consideration.

The real purpose of the quantitative analysis is to be able to rank the various investment opportunities that are made available to a company throughout the year. Through the use of certain standard analytical procedures, all investments can be put on a common footing so that a one-to-one comparison of each of the proposed investments can be made.

ANALYSIS CAN BE OVERRULED The results of the quantitative analysis can be overruled or ignored, whether favorable or not. There may be many overriding issues that will cause a company to make an investment when the financial analysis is not totally in compliance with that normally required for an investment. For instance, if a company can make an investment in a given opportunity and through that investment can attract dollars, possibly government dollars, into development areas in other locations of their company, then they may consider making the investment, even though the analytical analysis indicates that it is not the best possible use of those particular investment dollars.

Conversely, a company may decide not to make an investment, even though the analytical analysis indicates that it would be a reasonable investment. For example, it may be that the investment would be in an area in which there would be significant interaction with government agencies and by nature this may have been traditionally an area which the company has avoided. Consequently, even though it may be a good investment from an analytical analysis viewpoint, it will not be pursued because of the company's management philosophy.

In summary, the quantitative analysis provides a foundation upon which companies can compare available and competing opportunities for investment. It does not necessarily eliminate a potential investment from consideration, but it will provide insight as to what additional information and reasoning must be required to justify a positive final decision.

HANDLING OF QUALITATIVE ISSUES

The qualitative issues are those that cannot necessarily be presented analytically and placed in a quantitative format. These are typically the nonfinancial issues that must be recognized and considered on the basis of their potential impact. Often these issues represent the high-risk aspects of an investment.

Qualitative issues would include discussions on such items as the role of the government in the development of the industry. Is that role known, and what influence will it have upon the investment if a change in that expected role occurs? Other items would include the best timing for market entry; which major markets are best served; compatibility with corporate resources and objectives; strengths and weaknesses of competition; effective channels of distribution; relative size of domestic versus foreign marketplace; and many other issues. These issues are often a matter of judgment, opinion, or "gut" feel. Even if they are quantitatively presented, more often than not there is significant room for disagreement among various "experts" within the company.

COMPANY IMAGE IS QUALITATIVE ISSUE Qualitative issues also cover the area of company image. Is it an advantage or a disadvantage for the company to be in this particular investment area. Even if it appears to be a financially solid area in which to invest, it may be that governmental pressure or public opinion would be against a company moving into a certain area of investment. On the other hand, a company may be able to justify an investment in a marginal area because they will gain significant advantage through public relation avenues, and it may enhance their ability to sell other products that they already produce or attract additional government contracts that they might not otherwise obtain.

QUALITATIVE ISSUE CAN DOMINATE The discussions around the qualitative issues can often dominante the entire final investment decision process. This is especially true if the quantitative analysis is marginal in comparison to the desired minimum requirements of the corporation. It is in these cases that the interaction of the "champion" and the members of the ultimate decision-making group is very important. The relative knowledge of these final decision-makers and that of the "champion" on these qualitative issues may have the most dominant effect upon the investment decision.

3.6 COMPANY CHARACTERISTICS IN RELATIONSHIP TO DECISION PROCESS

CHARACTERISTICS OF VIABLE PHOTOVOLTAIC-ORIENTED COMPANY

OVERVIEW

To judge and compare the characteristics of various company types, there is a need to understand the characteristics of a viable photovoltaic-oriented company. There will be certain common denominators permeating all of the successful photovoltaic-oriented companies of the future. There will, however, be wide variations around each of these common denominators from company to company.

Through the discussion of these common characteristics of the future viable photovoltaic-oriented companies, a background will be presented by which present-day companies, both in and out of the photovoltaic venture, can be analyzed. Through this method, conclusions can be drawn concerning those present-day companies that would have a more optimum chance of being successful and enhance the possibilities for the overall national goals concerning the industrialization of the photovoltaic venture. Identification of other less optimum companies could result in having their potential enhanced through certain government actions, thus increasing the base of the number of companies capable of participating in the industrialization process.

Not only is this intended to assist in expanding the number of potential companies in the industrialization process, but it is also intended to give insight into what government actions should not be taken that might eliminate certain present-day companies from the industrialization process. By understanding the characteristics of the future viable photovoltaic companies, the government actions can be better designed and can avoid undesirable biasing of the future complexion of the photovoltaic industry.

STAYING POWER

The staying power of a company refers to its financial ability to support a long-range development program in the photovoltaic venture. Most present-day financial analyses of the photovoltaic venture indicate that short-term profits are not likely to occur, and in fact only marginal profits during the intermediate time are

possible. The long-term potential, however, of the photovoltaic venture is extremely optimistic. Thus to survive during the early and intermediate stages of the photovoltaic venture, a company must have the financial resources available to sustain its operation and support the research and development activities required.

INDUSTRY TREND DEVELOPING A significant and notable trend is already taking place within the photovoltaic venture. Small companies are formed based on technological capabilities and venture capital. Ultimately, these companies find that they can no longer finance the venture and begin seeking additional infusion of capital. If this is not done, the company ultimately loses market share and becomes a low-growth company. The source of the capital infusion has come primarily from large, multi-billion-dollar corporations which see the opportunities within photovoltaics but do not have internally the technological or production expertise to pursue the venture. Thus these large corporations have sought out these small technologically based companies which need capital financing.

There is no reason to think that this trend will not continue over the next five years. Few if any small companies will survive in the photovoltaic venture. Those that do survive will be based strictly on having found some unique niche in which they are capable of supplying specialized products to special markets with special needs but will in no way be able to supply the large quantity of products at the prices required for the bulk energy requirements of this nation.

SIMILAR DEVELOPMENT IN SEMICONDUCTOR INDUSTRY This route is commmon even within the semiconductor industry of today. During the 1960s, many semiconductor companies were formed with venture capital. However, in the 1970s many of these companies went out of business or were absorbed by larger corporations, principally the large computer companies and, more recently, large system companies from Europe. For those companies that have not been absorbed by larger corporations, they have remained in business by aligning themselves with large customers and in effect have formed a "marriage" relationship. The smaller semiconductor companies surviving today supply special products to system companies or have a significant share of their business being devoted to custom products that are not high enough in volume to interest the larger semiconductor companies.

The remaining large semiconductor companies have found that survival can only be through a vertical integration move in which they have evolved into producing subsystems and system products which consume large quantitites of their captively built semiconductor products. However, only the most profitable of the semiconductor companies have been able to finance this vertical integration movement.

FINANCIAL BACKING KEY TO SURVIVAL Thus one of the key elements of a future viable photovoltaic company will be its ability to obtain significant financial backing. In effect, the multi-billion-dollar corporations of today will be the ultimate viable photovoltaic-oriented companies of the future. It will be these companies that will set industry trends and directions, with the smaller photovoltaic companies surviving based on finding special niches in which they can participate.

TECHNOLOGY BASE

A key element of a viable photovoltaic-oriented company is its technology base. It must include the capabilities to continually investigate many avenues for technological breakthroughs on a long-term basis. This applies not only to the solar cell device itself, but also to the packaging technologies associated with photovoltaic products.

TECHNOLOGY MUST BE IN-HOUSE This technology base must be within the confines of the company. The long-term viable photovoltaic companies cannot rely upon having the technology made available to them through the public domain, even though government activities will attempt to provide that technology through such avenues. There must be in-house capability to develop independently the technology base required for long-term survival. It will be complemented by the information and the transfer of technology that is developed through government activities and research contracts in the public domain.

TECHNOLOGY ADVANCEMENT PROVIDES SHORT-LIVED ADVANTAGE The photovoltaic industry will be a high-technology-oriented industry. Traditionally throughout the culture of the United States, high-technology industries have always had associated with them a constant state of flux concerning personnel moving from company to company. The photovoltaic industry is expected to be characterized by this phenomenon also. The semiconductor industry, which is considered to be one of the high-technology industries in the US, is also characterized by this constant state of engineering and technical personnel changing companies.

The conclusion is that the proprietary nature of a given technology can only remain within the confines of a company for probably no more than one year. Through this constant change in personnel, the concepts and basic ideas of the technology will be spread throughout the industry. Thus a proprietary position can be maintained only for a limited time within a given company.

This is a principal reason why a company must have long-range technology development programs occurring at all times because once a technology advantage is obtained, it will only be an advantage for a limited time. Patent rights have not been a successful method by which a semiconductor company has been able to maintain a proprietary position. It is not expected to provide any significant protection within the photovolaic industry, either. This is especially true considering the federal government will be applying pressure through its policies, actions, and government contracts to have the technology base spread among as many companies as possible to enhance photovoltaic industrialization.

TECHNOLOGY CAN BE ACQUIRED There does not have to exist a technology base within a given company for it to decide to invest in the photovoltaic venture. Because of present-day government actions, spin-off companies being formed and the constant transfer of personnel within high-technology industries, a company desiring to enter the photovoltaic industry can do so without having an established technology base. It can be acquired through various means, including the acquisition route.

TECHNOLOGY ALONE DOES NOT GUARANTEE SURVIVABILITY While technology can be the link that draws a company into the photovoltaic venture, it will not in itself guarantee long-term survivability. If the technology is not pursued aggressively and technological breakthroughs accomplished, the company will find itself not remaining competitive in future years. Thus companies entering the photovoltaic venture based strictly upon their present technological expertise may find long-term survivability is still eluding them. Even then it must be coupled with other viable characteristics within the company. Technology alone will only provide a temporary benefit.

MARKET EXPERTISE

NEED TO UNDERSTAND MARKET CHARACTERISTICS Another important element to long-term survivability in the photovoltaic industry will be the ability to understand the market anatomy and the requirements of each major market served. The photovoltaic venture will no doubt draw companies into market areas that they have not traditionally serviced. Each new market area has its own unique characteristics, traditional methods of doing business, traditional channels of distribution, and required servicing aspects.

If a company entering a new market sector attempts to establish new methods of doing business, they will compound their penetration problems and increase their marketing cost. Only after thoroughly understanding how busines is done in a given market area should a company attempt to innovate or change those business practices.

PROPER IDENTIFICATION OF CUSTOMERS IMPORTANT One aspect of marketing expertise is to realize who the real customers are. For example, the actual end-user of a component or a piece of equipment may purchase it through a distributor. The distributer becomes the customer, not the ultimate end-user. Understanding these channels of distribution will enhance a company's ability to penetrate the market. By violating channels of distribution, a company tends to cause ill will and mistrust not only with the end-user, but with those intermedite companies that can introduce them to the high-growth sectors of the new markets.

In the photovoltaic venture, often the panel suppliers will deal with intermediate companies, namely the large functional systems companies, rather than the end-user. It is the identification of these large functional system companies and how they do business that will be critical to the long-term survivability of a photovoltaic-oriented company.

VERTICAL INTEGRATION WILL INFLUENCE BUSINESS STRUCTURE There are also vertical integration questions that must be resolved. If a photovoltaic panel supplier decides to vertically integrate and supply the functional systems that incorporate photovoltaic products, then that company must be prepared to implement an entirely new marketing approach compared to the selling of just the photovoltaic panels. The functional systems are sold in an entirely different fashion than components. If the company is not prepared for this difference in the marketing area, then significant delays and high expenses may occur before success is obtained.

At the same time, companies must recognize that the large system suppliers may vertically integrate in a downward fashion, taking away from the panel supplier certain added value aspects of their present business. For instance, a panel supplier quite often today supplies not only the photovoltaic panels to a systems company, but also specifies the batteries and in some cases even structural and interconnect material and may completely assemble and install a photovoltaic power supply at a given system's site.

However, as the systems companies become acquainted with how to design photovoltaic power sources, they will absorb the function of not only the designing of the power source, but the acquiring of the other components, such as batteries, interconnect material, structural material, and will install the power source themselves. This will remove certain functions from the panel supplier and the added value that the panel supplier was obtaining from supplying those components and services.

The panel supplier must thus be prepared for this inevitable occurrence. Being able to recognize which market segments are likely to pursue this downward vertical integration and those that will not pursue it will be a key element in preparing marketing strategies.

MUST FORMULATE MARKET STRATEGIES Formulating strong strategies in the areas of pricing, product definition, product diversification, and markets to be served will also be a critical element in the long-term survivability and profitability of a photovoltaic-oriented company. Only if the markets served are thoroughly understood can such effective strategies be implemented and maximize the potential profits that can be realized.

Another element in marketing strategies will be product guarantees. There must be an understanding of what minimum guarantees the market will require and what will the competition supply. In addition, will foreign suppliers provide greater guarantees than have traditionally been required in that marketplace? How is the guarantee to be supported will also be a critical issue. Will a repair function be provided? Will service personnel call upon the installation sites? Will an exchange of product be the manner in which the guarantee is backed?

Ramifications of the product guarantee policy will influence where inventories are warehoused around the world. Will the panel supplier maintain the inventory, or will the systems companies maintain it? Is the systems company to supply all needed services, or will the panel supplier have to be responsible for those functions? These and many other questions will have to be resolved before a successful venture can be implemented. The best approach in one market area may not comply with the requirements of another market area.

INTERNATIONAL ISSUES MUST BE DECIDED Since the photovoltaic industry will be a worldwide industry and a majority of the total market will be in non-US locations, a company entering the photovoltaic industry must decide what international capabilities they need. They must decide whether or not they will attempt to supply both the US domestic market and the international markets.

The implications of supplying a worldwide market are far greater than simply supplying the domestic market. If activities are restricted to the domestic market, the potential growth of the enterprise may be seriously restricted and will require a heavy involvement with the US government. A company must decide that this is acceptable to them. Supplying the international market, however, increases the number of competitors, as well as the distribution and marketing costs.

POLITICAL SAVVY

The successful photovoltaic-oriented companies will learn to work with a diverse combination of noneconomic elements, such as building codes, local utilities, government agenicies, insurance

firms, and a host of other issues. These items do not necessarily fall under a company's ability to do excellent marketing promotions. They fall primarily under the area of how to coordinate a large, diverse number of activities and meet a variety of possibly conflicting requirements. To a certain degree, this requires an excellent capability in the public relations area.

GOVERNMENT RELATIONS MUST BE DEVELOPED In the US, the federal government will have a significant hand in the development of the photovoltaic industry. In developing countries, the local governments will have the significant influece on what major photovoltaic-powered projects are installed. Throughout the entire photovoltaic market there will thus be a continual interaction with government activities and agencies. There will be no way a photovoltaic-oriented company can avoid the interaction with government policies, restrictions, and requirements.

A successful company will thus have to develop political savvy in how to deal with these various government contingencies. They must recognize that there are political overtones to this industry, and there will be no way to avoid them. The successful companies will have devoted a certain portion of their resources to understanding and developing relationships with key government agencies and personnel to maximize their penetration of various market areas.

As an example, many projects will have a government agency supplying the financial backing for the project. The company winning the contract will have had to have experience and knowledge in how to write and present proposals. Historically, the large system companies that have dealt with government agencies in many areas for years have been far more successful in understanding the proper fashion in which to write and present proposals for government contracts than most other companies.

EXISTING GOVERNMENT RELATIONSHIPS COULD BE USABLE ASSET It can be concluded that those companies that have experience in dealing with government agencies and supplying government products would have the expertise in the political area to be successful in a photovoltaic venture. While this experience in itself would not be sufficient to guarantee long-term survivability, it would represent a valuable asset within the company's resources.

It is not impossible to develop this expertise if it does not presently exist within the company structure. However, years of experience in this area cannot be accumulated overnight or learned from textbook theories or through casual acquaintances with key government agencies and personnel. It will be a painstaking and long-term project for a company to gain political savvy to enhance their position in the photovoltaic venture if it does not already exist within the company.

CHARACTERISTICS OF COMPANIES MOTIVATED TO INVEST

SEMICONDUCTOR-BASED FIRMS

TECHNOLOGY STRONGEST ASSET The first and most dominant characteristic of the semiconductor-based firms is their tremendous high technology base. This is probably their strongest asset in relationship to the photovoltaic venture. These companies have the largest accumulated amount of experience in dealing with the basic solar cell device materials of any industry or set of companies in the US. It is that base of knowledge that has allowed the technological development of present-day terrestrial solar cell products.

Based within most semiconductor companies are both near- and long-term research and development programs in the area of device physics and material characterization. These companies are well accustomed to rapid technological advancement.

The technology base that exists within the semiconductor industry is most applicable to only the solar cell devices themselves and not necessarily applicable to the packaging technologies that must be developed in the photovoltaic industry. The semiconductor industry is well experienced in the packaging of discrete semiconductor and integrated circuit components. They are not accustomed, however, to the packaging of large area products or the handling of large sheets of glass, plastic, and sheet metal. While they are very experienced in sealing techniques to produce hermetically sealed or water-resistant products, there is doubt that this expertise is directly applicable to the sealing and packaging of photovoltaic products.

STAYING POWER WEAKEST ASSET While technology is probably the semiconductor companies' strongest asset, it is their financial staying power that is probably their weakest asset. By far the majority of semiconductor companies are under the half-billion-dollar level in annual revenues, and only one company is in the billion-dollar range for their semiconductor operations.

Their financial success has historically been very cyclical and has been tied directly to the swings in the national economy. They are characterized as rapid expansion companies during good economic times and have resorted to rapid declines in employment levels during low or declining economic conditions. Few if any of the companies have acquired sufficient resources and financial power to maintain production and employment levels, and technical manpower during poor or declining economic periods.

Because of this lack of financial staying power, the demands within the semiconductor industry require that profits must be generated in the near-term period. If a new venture is to be contempated within the semiconductor industry, it must show excellent near-term financial return. For instance, within no more than two years it must be a profitable operation, or it will not be considered at all. Coupled with this is the requirement that the payback period on subsequent investments within those operations must also be less than two years, and hopefully less than 1-1/2 years.

BASE BUSINESS FIRST PRIORITY In general, semiconductor companies do not have the staying power to weather both the cyclic nature of their basic semiconductor business and finance the necessary capital investments required for a long-term photovoltaic venture. The semiconductor companies recognize this, and consequently there have not been any significant number of semiconductor companies entertaining serious thoughts of entering the photovoltaic venture. The short-term payback and profit potentials simply are not attractive enough to even consider such an investment if the basic business is to be maintained.

What few semiconductor companies have entered the photovolaic industry or are considering entering it have done so because of other motivations. One of these motivations is that government funding is available in the area of material technology development, an area that is directly applicable to activities already established within their research and development activities. By having federal funding develop the material technology, the overall investment required by the semiconductor companies is thus significantly reduced.

In addition, the investment in the photovoltaic venture to date has not necessarily required the installation of additional production capacity in certain key areas, such as facilities, wafer production, wafer processing, and cell development. Once significant quantities of capital infusion are required from the company funds generated internally and additional production capacity is required to sustain the growth of the photovoltaic venture, the semiconductor companies presently in the photovoltaic industry will have to seriously reconsider what their future strategy and commitments are to the photovoltaic industry. In no way will they allow the photovoltaic venture to seriously jeopardize their profit position, especially if there is a downturn in the nation's economic environment that may cause a retrenching or constriction of the base semiconductor business.

MARKETING EXPERTISE LIMITED TO COMPONENT EXPERIENCE In addition to the moneys being made available in the material investigation areas, the limited number of semiconductor companies that are seriously considering the pursuit of the photovoltaic venture also have vested interests in functional systems operations

either as part of their semiconductor operation or as a separate division of their parent corporation. These functional systems businesses are viewed as a readily available market for any photovoltaic products that may be produced. This affords these semiconductor companies a reduction in the potential investment in marketing capabilities that might otherwise have to be developed from scratch.

The majority of the semiconductor companies' experience in the marketing area, however, has been associated with the marketing of components and not that of functional systems. Most semiconductor firms do not have applicable systems divisions within the same corporation that can possibly bridge this area of needed experience. Consequently, if a semiconductor company does consider the photovoltaic venture, it will most likely consider it from the viewpoint of supplying a component to a functional systems house. The component would be either the photovoltaic device cell or a photovoltaic panel. Because of their lack of marketing expertise in the systems marketplace, few if any will be interested in the photovoltaic venture. The opportunities for vertical integration into the systems business are too restrictive in this particular case compared to the opportunities for vertical integration in the semiconductor industry.

VERTICAL INTEGRATION REQUIREMENTS NOT COMPATIBLE

Vertical integration tendencies in the semiconductor industry is based on the fact that the products such as minicomputers and computers contain a high degree of semiconductor products, both dollar-wise and in technology content. That is, a significant contribution to the overall system characteristics are provided by the semiconductor components. The additional technologies and capabilities that must be added in the vertical integration move into a completed instrument or a subsystem or a minicomputer is not as extensive as compared to the semiconductor technology base.

However, in the case of a photovoltaic-oriented company devoting its efforts toward vertical integration, the case is entirely different. The photovoltaics represent a relatively small contribution to the overall technology base and dollar content of the complete functional system.

Thus to approach vertical integration from a base of photovoltaic panel manufacturing requires the addition of many manufacturing capabilities, technology inputs, marketing expertise, and significant financial investments. The tendency for vertical integration is thus not as great within the photovoltaic-oriented company, as in the case of the semiconductor company. Consequently, semiconductor-based companies will tend to stick with those areas in which vertical integration can be easily accomplished and in which the semiconductor components contribute a significant portion to the overall system function. Photovoltaics does not appear to offer that advantage to a semiconductor company.

PLANNING HORIZON RELATIVELY SHORT Historically the semiconductor companies have not extended plans, objectives, or goals beyond a five-year horizon. With very few exceptions, firm, long-range strategies are not a commonplace occurrence in the semiconductor industry. Thus with planning not extending beyond the five-year horizon, commitment of funds to investments that may require greater than five years to recoup would be intolerable in a semiconductor-based company. The photovoltaic venture today does not offer any reliable short-term profits or return on investment that is at all compatible with the semiconductor industry planning cycles and general financial requirements.

Marketing programs, strategies, and deployment of resources are not geared or oriented toward such long-range planning. The principal reason is that the cyclic nature of the nation's economy tremendously affects the operational nature of the semiconductor industry. They simply cannot afford to commit their resources to such long-range firm commitments as is required within the photovoltaic industry without seriously jeopardizing their base business posture. There are exceptions to all of these cases within the semiconductor industry and there is a tendency for such companies to begin looking beyond the five-year horizon; however, these are very limited exceptions and can be scuttled, dropped or changed if any serious economic conditions develop.

NEW MARKETS CAUSE PROBLEMS There has been a tendency for the semiconductor companies to fail to understand new markets. Often new markets are approached with the same philosophy, product supply channels, and methods of operation as have traditionally worked in supplying components to the computer-oriented marketplace.

An example of the semiconductor industry failing to understand the characteristics of the market is exemplified by their approach to the consumer electronics business, especially the watch industry. Virtually all of the American semiconductor companies have experienced a failure at the digital watch market due to a lack of understanding of methods of distribution, financing, and consumer desires.

The semiconductor companies will have tremendous marketing problems in entering markets served by the photovoltaic venture unless they are willing to adapt to the traditional methods of doing business within those marketplaces. Each marketplace will have its own special characteristics. The marketing expertise of semiconductor companies is not broadly based enough in most cases at the present time to comprehend and encompass all of the many and varied marketing conditions that will have to be met by photovoltaic-oriented companies. Those that learn to adapt to this condition will have significantly increased potential for long-term survivability, but it will be a stress on most semiconductor companies' financial and marketing resources.

INTERNATIONAL ASPECTS NOT A SEVERE LIMITATION

The photovoltaic venture will require companies to operate in the international domain. The bulk of the sales at the panel level will be to the functional systems firms throughout the world. These firms are generally located in the industrialized nations of the world, while the final installation of the photovoltaic products will in most cases be in developing countries.

The sale of the product through the first channels of distribution will be in the industrialized countries. Here the semiconductor companies have compatible distribution and marketing methods. They are accustomed to doing business in virtually all of the industrialized nations and are well aware of the existence of the functional systems firms, their locations, and some information on the types of products they buy. For this reason, the semiconductor industry would have an advantage over other types of companies that are not accustomed to doing international business.

The US semiconductor firms also have manufacturing plants in Europe, the Orient, and South America. This could become a great asset if manufacturing of photovoltaic products is required within certain countries to attract the business that is available there. New small photovoltaic companies being formed would not be able to distribute their product as cost-effectively in these industrialized nations as would the semiconductor-based companies that already have manufacturing, distribution, and marketing connections within such countries.

GOVERNMENT RELATIONS NOT OPTIMUM The semiconductor industry has historically viewed the federal government as a restrictive force upon their industry rather than an ally. The nature of the semiconductor business requires great flexibility to react to both competition and market conditions. In effect, the semiconductor companies tend to feel they cannot control their own destiny if they are within a market where the government has the dominant influence.

During the early years of development of the semiconductor industry, the federal government played a key role in that they were a major purchaser of semiconductor products. However, the commercial ventures became far more attractive for the semiconductor companies, and they have consequently concentrated on these particular markets during the last fifteen years.

They still continue to do business with the government agencies, but such business is not a dominant portion of their overall business position. Virtually all sales to government agencies require a tremendous amount of paperwork, traceability, additional steps deemed unnecessary by the semiconductor industry, and in general a lack of flexibility in moving inventory and resources.

The semiconductor industry has not learned to deal with the government agencies in a fashion that causes them to be viewed as an ally or as a positive aspect in their overall business. The government's presence in the photovoltaic venture will be significant if not totally dominant for at least the next five to ten years. In general, this would act as a restrictive force in encouraging semiconductor companies to enter the photovoltaic venture.

SUMMARY OF ASSETS AND DEFICITS In summary, those assets that the semiconductor industry has that would benefit or aid them in the photovoltaic venture would include:

- High technology base
- Capability to market internationally to systems companies
- International manufacturing experience

These assets, however, are offset by certain negative tendencies, which include:

- Limited financial staying power
- Lack of a firm and positive relationship with government agencies
- Lack of marketing experience in a large number of markets
- Inadequate long-range planning practices

To induce semiconductor companies into the photovoltaic venture, the objectives of the government actions and policies should be to reduce the financial requirement of the photovoltaic venture, develop a working relationship with the semiconductor industry, leave the industry capable of determining their own destiny, and to inform them of marketing practices, distribution channels, and other pertinent information concerning new markets that will be required in the photovoltaic venture.

PETROCHEMICAL FIRMS

The petrochemical firms are the large US oil companies; those responsible for supplying the nation with the various forms of oil, fuel oil, gasoline, and the many biproducts of the oil industry.

GREATEST ASSET IS STAYING POWER In relationship to the photovoltaic venture, one of the greatest assets that these companies offer is their tremendous staying power. Their financial resources are among the largest and most broadly based of any grouping of industrial firms within the United States.

Because of their tremendous staying power, they are prepared to meet the requirements of firm long-range plans and strategies. By long-range plans it is meant planning in excess of a ten-year horizon and as far out as a twentyto twenty-five-year horizon. This style or type of long-range planning is standard operating procedure within this industry.

If the long-range potential is sufficient, then the short-term prospects will not restrict such companies from making the necessary investments and devotion of resources that may be required within the photovoltaic venture. This does not mean that there will be a total disregard for the short-term operational procedures, but it will not act as a restrictive element as in the case of the semiconductor industry.

MARKETING EXPERTISE BROADLY BASED The marketing expertise required in dealing with a spectrum of widely varying market conditions is well developed within the oil companies. They are accustomed to international marketing, manufacturing, and distribution.

They not only have distribution channels within the industrialized countries but also have similar capabilities within the developing countries, or at least access to such potential channels. The movement of raw material and products from one location to another throughout the entire international scene is an everyday occurrence for these companies. The development of special products and special packaging is also common within these companies for a wide variety of market conditions. The concept of handling a large number of different types of products as well as the distribution of such products will be a valuable asset to these companies within the photovoltaic venture.

The diversification of this industry is extremely broad based, ranging from mining to farming operations, controls, electronics, office equipment, biologically based operations, and a host of many other areas of endeavor. While no one oil company is this widely diversified, each is still significantly more diverse in its operation than compared to semiconductor-oriented companies.

GOVERNMENT RELATIONSHIPS MIXED The oil companies over many decades have learned to develop political savvy, both domestically and internationally. While it has been extensive in nature, it is not altogether totally positive. Especially domestically, there is still a lack of trust on their part that the US federal government will continue to be supportive of their actions. Their relationship could be described as one of appeasement and compromise rather than an aggressive partnership with the government.

It is because of this fear concerning a lack of continued support or an increasing restrictive nature that the significant diversification programs have been implemented within these

companies. The oil firms recognize that in the future the oil industry will become far more controlled and restricted by government regulations. Consequently, to protect their stockholders and investment and to assure a continued high-growth future perspective, the diversification in other industries was begun. Industries are selected that represented both high growth and a lack of government involvement. This should not be interpreted as meaning they will avoid an industry in which the government is heavily involved, but it will have to offer significant long-term, high-growth potential to attract them.

TECHNOLOGY BASE WEAKEST ASSET While staying power, marketing expertise, and the ability to handle government relationships are strong assets of the oil companies, without doubt their weakest asset in relationship to the photovoltaic venture is their technology base. This is almost the complete opposite of the semiconductor picture.

The development of the technology base within the oil companies, however, is on an aggressive corrective path. As previously mentioned, technology can be brought into a company's resources through either internal development or the acquisition route. Both of these avenues are being pursued by the oil companies. Since the solar cell device technology is the most widely known and publicized and through being diversified into the electronics industry, it has been a relatively easy job for any oil company to obtain the required technology expertise.

In the packaging of these solar cells, the oil companies appear, however, to have no tremendous advantage or disadvantage compared to the semiconductor industry. Due to their large diversification program, they do hold the potential of resolving packaging problems more readily than most other firms would.

VERTICAL INTEGRATION BEING CONSIDERED The vertical integration issues for the oil companies are very similar to those previously discussed for the semiconductor companies, except that the oil companies do have the financial resources to accomplish any vertical integration program that they may deem critical to the success of their photovoltic program. At present, those oil companies participating in the photovoltaic venture have been satisfied with manufacturing photovoltaic panels and supplying the other required components to produce a photovoltaic-powered power supply for various applications.

Each one is, however, seriously looking at what the prospects and the requirements are for a vertical integration step into the functional systems area. Some are better prepared for this vertical integration step because of other diversification programs that have preceded the investment in the photovoltaic venture. None, however, are completely aligned with a readily available division or subsidiary that would allow a direct vertical integration movement at the

present time. The continuation of their diversification program, however, could bring about the acquisition of a functional systems company that may have direct requirements for photovoltaic power supplies.

TECHNOLOGY BASE EXISTS IN OTHER COMPONENT AREAS Many oil companies have technology development activities occurring in areas such as batteries that could be applied directly to the photovoltaic venture. To date, the bulk of the battery technology activities have been directed toward the electric vehicle, load-leveling functions, and consumer products. However, such efforts could be redirected toward the photovoltaic venture if and when a significant technological breakthrough is envisioned.

Another major component of future photovoltaic systems will be the power conditioning electronics involved in such systems as residential, electric utilities, commercial, and institutional facilities. Most of the efforts in power conditioning to date within the oil companies have been devoted primarily to the simpler systems that may apply directly to present-day applications in the communications, cathodic protection, and water pumping areas. Additional efforts and resources are being devoted to power conditioning, but not to the degree and intensity of the battery and solar cell device developments. The prospects and the capabilities, however, do exist for elaborate technology efforts in this area within the oil companies.

OIL COMPANIES POSSIBLY BEST EQUIPPED FOR PHOTOVOLTAIC VENTURE The US oil companies bring many valuable assets to the photovoltaic venture. Excellent expertise in virtually all areas of the previously described viable photovoltaic companies are met by the oil companies, with the exception of the technology base. The development of the technology base, however, is rapidly being acquired, especially in the area of the semiconductor-oriented portion of the photovoltaic products.

It would thus appear to be in the best interest of the national goals to continue to encourage these oil companies to proceed at a rapid pace in the development of a complete photovoltaic venture. It is not, however, necessarily in the interest of small business to encourage these large corporations, but the ultimate photovoltaic venture is not and cannot be considered a small business affair. Small businesses should be encouraged to develop, but with the idea that they will ultimately either be bought out by large multi-billion-dollar corporations or they will satisfy the relatively small but profitable special requirements within special market areas. Such small businesses cannot effectively, efficiently, or economically supply the vast quantities of photovoltaic products that will be required to resolve any national energy requirements or even a portion thereof. Of the available industry types, the oil-producing companies bring the greatest number of assets in a

well-developed form to the forefront of the photovoltaic venture. It would require fewer government actions and policies to complete the entire resources required by these companies to industrialize the photovoltaic venture.

PHOTOVOLTAIC VENTURE NOT ATTRACTIVE TO ALL OIL COMPANIES

Not all oil companies will find the photovoltaic venture attractive, regardless of what government actions are taken. A principal reason will be that the product requirements are too diverse from the overall corporate objectives of their diversification programs.

Another reason for not pursuing the photovoltaic venture will be the fear that the presence of the federal government in such a dominant role will cause this industry to become just as regulated and restrictive as are the perceived prospects for the oil industry. Consequently, they will be seeking areas of investments that will be outside of the energy-oriented business, such as electronics, medicine, consumer products, and business equipment.

MATERIAL-ORIENTED FIRMS

Reference here is being made to those material suppliers principally in the silicon business. Additional materials companies that could show interest in the photovoltaic venture are those suppliers of other basic materials that may be used in the photovoltaic products. Such companies would include suppliers of aluminum, glass, gallium, cadmium, plastics, and various materials for encapsulation.

TECHNOLOGY BASE VARIED BUT GENERALLY DEFICIENT

The technology base for these companies is associated with their ability to characterize, produce, and distribute basic materials that will be used in the photovoltaic venture. Their technology base may not necessarily be in the solar cell device area. This is especially true when considering their ability at the production aspects of solar cell devices as compared to the semiconductor companies.

The packaging aspects of the photovoltaic venture are even further removed from their basic area of expertise in technology and manufacturing. There are those material firms, however, that are very diverse and include material capabilities in other areas that they could draw upon to develop the necessary packaging capabilities. This is similar to the oil companies through their diversification programs.

Because of the high technology content devoted to solar cell device manufacturing capability, the present-day photovoltaic products have not attracted the materials companies to the forefront. This area of endeavor appears to be incompatible with presently developed technology skills and expertise.

FUTURE HOLDS MORE FAVORABLE PROSPECTS Future photovoltaic products, however, may offer a more attractive picture to these companies, especially once the technology has been reasonably stabilized and the products demand the capability of large-area production and handling of basic materials. This is especially true of the glass, aluminum, plastic, and other nonsemiconductor-oriented material companies.

The acquisition of the cell technology could very well be accomplished through the joint venture, acquisition, or internal development routes. The joint venture route has been and will continue to be the route in which the glass, plastic, aluminum, and nonsemiconductor companies acquire the necessary expertise in the photovoltaic venture. The silicon and semiconductor-oriented material firms will choose the internal development or acquisition route as their means of acquiring the necessary technology. Emphasis will probably be upon the internal development route.

MARKETING EXPERTISE NOT COMPATIBLE WITH PHOTOVOLTAIC VENTURE The marketing capabilities of these material-oriented companies varies depending upon which material dominates the company. The silicon and other semiconductor material firms have developed marketing expertise devoted to the steel, aluminum, and semiconductor industries, with the semiconductor industry being the smaller market serviced. The nonsemiconductor-oriented materials companies have developed a larger customer base and a larger number of markets served than have the semiconductor materials companies.

The materials firms have devoted their marketing expertise to meeting the needs of basic industries rather than the systems companies. Thus the photovoltaic venture would require the development of marketing expertise to customers and market segments that these firms are not traditionally accustomed to servicing. Their ability to meet the requirements of these new markets is relatively untested. In addition, they have not been known for their dynamic and aggressive pursuite of new markets. This is not to say that they cannot accomplish this function. Many of the material companies are owned by larger multi-billion-dollar parent companies that have tremendous resources through diversification programs that could bring a base of accumulated experience to bear upon their ability to market to new areas.

MAIN RESTRICTION IS PRODUCTS TOO DIVERSE The most likely restriction of these companies in their pursuit of the photovoltaic venture will be an incompatibility of the photovoltaic products and the markets to be served with overall corporate objectives. Most are not systems-oriented, nor are accustomed to adding additional components to their products to enhance their sales.

INTERNATIONAL EXPERIENCE OFFERS LITTLE BENEFIT Many of the materials firms are international in scope as far as sales and distribution capabilities are concerned. Few, however, have international manufacturing capabilities or a tendency to develop them. Where international manufacturing capability has been developed, it has been more closely aligned with the nonsemiconductor material companies. Where international manufacturing has been established, it has been for the purpose of supporting basic industries within those countries rather than serving new markets or functional systems-oriented companies.

LONG-TERM PROSPECT ALONG LINES OF SUPPLIER TO PHOTOVOLTAIC FIRMS To date, most materials firms have been satisfied with simply supplying materials to the photovoltaic industry rather than making completed photovoltaic products. This does not mean that they have not considered the photovoltaic venture. Several have made significant investments internally in the photovoltaic venture, pursued joint ventures, or have been heavily involved in government developmental contracts.

The long-term attraction to the materials companies is that ultimately a significant business could possibly be developed in supplying basic raw materials to the photovoltaic industry. None envision the photovoltaic materials business as a stand-alone business. It must be viewed as an additional market to be serviced, as its future potential does not justify the investment in new facilities and equipment, especially in the short-to intermediate-term future. Long-term prospects may ultimately alter this position.

POLITICAL SAVVY COULD BE DEVELOPED Since the major business activities of material companies is primarily serving basic industries of industrialized countries, the need for the development of political savvy has not necessarily been a major part of their previous business activities. It has not necessarily been needed, but at the same time it does not appear to be beyond their capabilities of developing.

Because they are aligned with supplying basic industries of industrialized countries, they are generally looked upon in a favorable light by the national governments of the various countries in which they do business and in general are not viewed in a negative fashion by the public. The pursuit of the political savvy required within the photovoltaic venture would be upon the basis of developing it on a partnership basis with the government agencies and the various governmental bodies, since no fear of the government dominates their thinking, as in the case of the oil companies.

STAYING POWER AVAILABLE In most cases, the financial staying power is available within the materials companies. It is not always obvious, but it must be remembered that these material companies are generally part of a multi-billion-dollar corporation. The key to the use of those financial resources, however, is in the perceived compatibility of the photovoltaic venture with the normal corporate objectives.

It has been and will continue to be very difficult to lure these conservative materials-oriented companies into market areas that are very divergent from their basic business. Those material firms that are part of corporations with diversification objectives will be the most optimum companies and the most likely to pursue the photovoltaic venture.

MATERIAL FIRMS TO PLAY SUPPORTIVE ROLE ONLY Too many of the critical assets are lacking in developed form to expect the materials companies to play more than just a supportive role in the photovoltaic venture, especially with present-day product forms. In the long term, when the product form changes and it is more oriented to the production of large-area sheets of basic materials, there may be more compatibility with the mass-production capabilities of these materials companies.

For the short term, however, there seems to be only a limited number of materials firms that are willing to risk the investment. It will be difficult to development government actions and programs or policies that can overcome the basic conservative viewpoint of materials firms. The constant encouragement of these firms through the awarding of governmental developmental projects and contracts may be the most productive method of luring these companies into the photovoltaic venture.

FUNCTIONAL SYSTEMS FIRMS

Frequent reference has been made in previous sections to the functional systems companies as the predominant customer base for photovoltaic-oriented products. It is not beyond consideration that the functional systems companies may wish to vertically integrate in a downward fashion to incorporate the photovoltaic manufacturing function. The key to this prospect is the level of requirements for photovoltaic products within that company.

PROSPECTS VARIED WITH RESPECT TO ENTRANCE The types of companies in this category would include the suppliers of microwave communication, cathodic protection, water pumping, controls, energy storage, and electric utility equipment. The prospects of these functional systems companies entering the photovoltaic venture is

extremely varied. Certainly, the bulk of these companies will ultimately find uses for photovoltaics within the products that they supply. As a result, there will be a minimum effort toward vertical integration in the majority of these companies, especially in the downward direction of at least developing the capability to design photovoltaic-oriented power sources, and directly obtain the balance of system components. This function is presently performed by the photovoltaic product suppliers.

CAPABILITIES UNCLEAR IN STAYING POWER It is difficult to identify any general trends in the area of financial staying power of these companies. Within each of the general systems categories previously mentioned, there is a multitude of various-sized companies. Some are independent companies, while others are owned by larger corporations. The functional systems aspect of their business may not be the dominant portion of the company's central business position. There is, however, within each of those basic categories those companies that do have the financial resources to accomplish the photovoltaic venture.

TECHNOLOGY BASE WEAK, JOINT VENTURE OR ACQUISITION NEEDED The technology base as it relates to the photovoltaic technology within these companies is usually limited or nonexistent, as their function has not been the development of power sources but rather the use of them. If a company within one of the system categories does decide to vertically integrate in a downward fashion, they will accomplish it through the acquisition route, a joint venture, or some long-term contract with a photovoltaic product supplier.

It is unlikely that these companies will attempt to develop the photovoltaic venture internal to their own organization. If their captive needs are sufficiently large, the easiest, quickest, and most efficient route for them would be to join forces with an existing photovoltaic supplier through some means.

The majority of their internal development work has and will continue to be devoted toward developments of systems rather than the individual components within that system. There are certainly exceptions to this general statement, as would be exemplified by the electric utility equipment supply firms.

MARKETING EXPERTISE STRONGEST ASSET In relationship to the marketing aspects of the photovoltaic venture, these companies are already well established in this area, either through captive needs for photovoltaics or in their long-term relationship with the major end-users of systems. These firms have close ties with the ultimate bulk energy markets of the future, which include areas such as:

- Communications
- Agriculture

- The electric utility industry
- The powering of commercial, institutional, and industrial facilities
- The support of infrastructure developments in the lesser-developed countries

Thus the addition of the photovoltaic aspect to their business would not require a heavy investment in the marketing area, especially if captive needs or the serviced market requirements are significant.

The ability of these companies to distribute hardware and services throughout the world is already well established. The addition of supplying and distributing photovoltaic hardware and the servicing of that hardware would not be a serious restriction.

GOVERNMENT ACTIONS TO HAVE LIMITED INFLUENCE It will be difficult for government actions or programs to induce these companies to invest in the photovoltaic venture at the early stage of industrialization. The photovoltaic content of their end products is relatively small and would require a sizable investment compared to the possible benefits.

GOVERNMENT ROLE IN ENCOURAGING INVESTMENT

PARTNERSHIP NEEDED BETWEEN GOVERNMENT AND INDUSTRY It has been implied by the above discussions that there does not appear to be any particular industry grouping today that meets all of the requirements for the viable long-term photovoltaic-oriented company. Each company or industry type has assets and deficits. Survivability in the photovoltaic venture will depend upon several parameters and not just one or two selected ones. No company can expect long-term potentials to be accomplished if they do not bring to bear the necessary resources in all of the mentioned areas.

The photovoltaic venture is not a simple one, and yet it is not beyond the resources of American industry. It should also be recognized that it is not beyond the resources of foreign countries and their industries. In most cases, foreign governments have formed partnerships with their industries in many areas of endeavor, and it is not beyond expectation that the photovoltaic industry will be supported on a partnership basis by these foreign governments. Thus there is the added pressure that the US government and its agencies should endeavor to establish a positive nonrestrictive working relationship to accelerate the industrialization of the photovoltaic venture.

OBJECTIVE SHOULD BE TO FOSTER POSITIVE ENVIRONMENT

The methods by which the industrialization will take place within various companies is through internal development, acquisitions, joint ventures, long-term contracts, and other innovative "marriages" between companies. The objective of the government actions and policies should be to foster an environment in which these routes of endeavor can be more easily pursued and encourage the joining together of assets of various companies to meet the overall requirements of the photovoltaic venture.

The independent development of the necessary assets by each company will prolong the industrialization period. If, however, an environment is so created by government policy that the assets from each of several companies can be brought together within the confines of a series of photovoltaic-oriented companies, then the time frame required for the industrialization period will be significantly reduced. A likely result of this will be the rapid development of only a small number of highly efficient but extremely large photovoltaic-oriented companies.

During the foreseeable future, the trend is for the emergence of a number of independent photovoltaic companies, most of which will not have the financial staying power referred to in earlier sections. Their development will be needed to act as seed companies that can later be acquired by those firms having both the marketing and financial expertise required for the long-term survivability. Through this route, the industrialization program and the desired production of photovoltaic products to meet the national energy requirements are compatible with the requirements of industry to meet financial reward requirements on the part of the stockholders. It also allows for small businesses to develop even though they will ultimately be absorbed.

The ultimate timing of meeting those requirements, however, may not be compatible with national photovoltaic goals and objectives. It can certainly be stated that government policies and actions could very easily delay the ultimate industrialization of the photovoltaic program. Careful consideration of all programs and policies will have to be pursued such that the detrimental effects do not override the intended positive influence.

3.7 PERCEIVED INVESTMENT BARRIERS

OVERVIEW

The insights to the motivations to invest, the elements of the investment proposal process and the final decision environment, and company characteristics lead to the identification of investment barriers. There are no two companies in the US industrial complex that are uniquely alike. They each have their own special characteristics, history, tradition, and personality. Thus what may appear to be a barrier to one company may not be considered a serious barrier to another company. Generalizations can, however, be made along with some observations concerning the perception and types of barriers that are encountered.

PERCEPTION OF BARRIERS CAN CHANGE It is important to realize that barriers to the entrance into a given investment opportunity are subject to judgment. Barriers are perceived and subject to interpretation. Predicting how one specific company will react to a given policy designed to reduce the height of an investment barrier is extremely difficult if not completely impossible.

The judgment aspect associated with a perceived barrier can change strictly with a change in personnel at the critical positions within a corporation, even though the financial, market, and physical characteristics of the opportunity did not change at all. Thus what could appear to be an excellent investment opportunity as fostered by a government action or policy may at a later date result in an almost opposite interpretation.

A high-technology-oriented company directed by a one-man final authority having a technical background may view the photovoltaic venture as an excellent opportunity. However, change that final authority to a financially-oriented individual, and that same corporation may have an entirely different interpretation of that same photovoltaic investment opportunity.

TWO TYPES OF BARRIERS It is difficult for a company to reverse its decision once an investment has already been made, especially if it is an extremely large investment. It can occur, however, and it will usually follow the route of selling a division or a given investment program to some other corporation, especially if it has reached the point at which the investment can be identified and segregated from other corporate activities.

To avoid the reversal of a major decision and possible significant financial losses, companies will often spend large sums of time and money to ensure the proper decision is being made. The degree and specific nature of the investment is not generally the principal concern. The issue will center around whether the proposed investment area is something the corporation wishes to pursue.

Companies that are not completely sure of their ultimate participation in a given investment area may pursue it in the series route or series parallel route, as described in the early sections of this chapter. In this fashion, they can hold down their investment until they have resolved other barriers that may be restricting them from a more aggressive pursuit of the investment opportunity.

Thus barriers can take the form of either absolute barriers that completely keep a company from making an investment, or they can be secondary barriers that influence the manner in which they make the investment. These secondary barriers may also be of sufficient size to restrict the company from making any investment whatsoever in the photovoltaic venture. The absolute barriers can be thought of as being more definitive in their results in that they either allow an investment consideration to proceed forward, or it rejects it entirely. The secondary barriers tend to be more a matter of degree and center around the form of the investment.

A B S O L U T E B A R R I E R S

LOW FINANCIAL REWARD

A low financial reward can be perceived as a result of two basic items. First, the return in the proposed venture area may be smaller than other opportunities that are made available at the same time to a given corporation. The second factor is that if present investments are yielding considerably higher returns than the proposed venture, then the venture may be delayed or rejected in hopes that better opportunities will occur in some other area. The mix of present investments can thus set the minimum standards for any future investments.

In virtually every corporation of any substantial size, there are always several investment opportunities provided throughout the fiscal year. The photovoltaic venture, for example, will always be in competition for the attraction of investment dollars and resources, no matter when it is considered. In the larger corporations, it may find competition from several hundred opportunities, while in the smaller corporations the number of competing opportunities will be somewhat limited, perhaps less than a dozen. Thus there is ample opportunity to compare the photovoltaic investment against many other opportunities.

Distinction should be made between financial risks and a perceived low financial reward as a barrier to investment. A financial reward is based upon those quantitative parameters that can be calculated and evaluated on a sensitivity basis. A given financial reward for an investment may be accepted, but that does not guarantee that the calculated reward will be obtained. Even a perceived high financial reward has financial risks associated with it in that many factors may develop in the future that could jeopardize the attainment of that reward. Regardless of the value of the reward perceived, there are always associated risks.

Any government policies or actions that are developed will need to reduce the investment base on which the financial reward is considered or increase early revenues for the same investment level. This would, in effect, cause the financial reward to appear larger. Any actions that may influence the early acceleration of market development would have the effect of increasing early revenues for the same investment and also act as a reduction to the low financial reward barrier. A reduction in risk through government actions will also enhance investments that might otherwise be limited or delayed.

MARKETS OR PRODUCTS NOT COMPATIBLE

The second absolute barrier is that markets or products are not compatible with corporate objectives. In effect, it states that the relationships of the photovoltaic products, markets, or customers are too diverse from the present and future desired business complexion to deserve any significant consideration at the present time. This does not mean that there will not be any monies at all devoted to the photovoltaic venture. It simply means that the degree or level of investment will have to remain as a budgetary item within some business unit or research and development activity.

It still leaves open the possibility for the attraction of continued government projects or contracts, especially in the technology or materials development area. What it specifically means is that no separate organization, manpower, resources, or financial support will be devoted to the photovoltaic venture other than to keep the company abreast of the developments within the industry. This would be very typical of many of the materials and semiconductor companies in viewing the photovoltaic investment venture.

Still other companies may consider the photovoltaic venture so diverse that not even minor budgetary monies should be spent on the subject area. This could very easily be the viewpoint of most companies outside the materials and semiconductor industries. It will be extremely difficult for any government action or policy to be developed that will overcome this absolute barrier.

SECONDARY BARRIERS

HIGH-RISK--TECHNOLOGY

One of the most common barriers to a company making an investment in the photovoltaic venture is the possibility of having a present-day technology obsoleted in a relatively short time frame. This is especially true if significant dollars are required for automation to reduce product cost. A significant technological breakthrough in either packaging or solar cell device concepts could obsolete the automated equipment.

Even if automation is not involved, there are other significant financial investments to be made in equipment if high production quantities are to be delivered. To support a high-volume production line in the near term or early portion of the intermediate market, large quantities of equipment must be put in place. The threat of a technological breakthrough requiring entirely different equipment could foster a fear in the minds of the responsible individuals of a corporation to delay making the investment in the photovoltaic venture.

The long-term perspective for photovoltaics is that technology breakthroughs must occur if significant strides in cost reduction are to be obtained. With this in mind, many corporations will be reluctant to make the necessary financial investments in this opportunity. There will be a tendency to wait until the technology is developed. Only those companies with sufficient financial staying power will be able to justify the investments in the near- or intermediate-term time frame. In most cases, a company investing in the photovoltaic venture will do so with the long-term perspective that technological breakthroughs will occur and that equipment implemented during the early phase of the photovoltaic venture will ultimately be obsoleted.

The design of government actions must be in such a manner as not to bias the industry toward certain companies, nor to eliminate the pursuit of future viable technologies. Any action on the part of the government to advance the technology will heighten the risk of technology obsolescence. If, however, technology advances are not supported by government actions, then step functions in cost reductions may not occur soon enough to meet national goals.

HIGH-RISK--MARKETS

The principal concern associated with this barrier is the timely development of sufficiently large markets to support the photovoltaic venture and to provide adequate return on the investment, at least over a long period of time. The proper and accurate identification of markets is key in the evaluation of the photovoltaic venture. Special characteristics of markets must also be taken into consideration. The rate at which the technology and new products can be transferred to the market, the methods of doing business, and several qualitative issues may heavily influence the perception of the risks.

Many markets for photovoltaic applications have been identified. However, what is often missing is the identification of the basic driving forces that guide the development and growth of the market. These are needed to assist the prospective company in understanding how a sufficient penetration of photovoltaics is possible. The improper or inadequate identification of markets by the government may discourage prospective companies from entering the photovoltaic venture. A series of insufficient market forecasts could cast serious doubt upon the entire photovoltaic venture, even though excellent markets may exist in the long run.

Another limiting aspect in prospective photovoltaic market developments is the presence of other competing technologies that may limit or completely restrict the penetration of photovoltaic products. The market analysis must include a thorough analysis of the economics and the qualitative issues associated with these other technologies that are presently servicing that market or would come to bear under different market conditions. The company investing in the photovoltaic venture must be knowledgeable and aware of all of the contingencies such that they can make the necessary plans, strategies, and product definitions to effectively compete against these technologies.

There is also the fear that a market may disappear. This is especially true in relationship to government markets or markets that are heavily influenced by government regulations. There are fears, doubts, and uncertainties associated with what the long-term position of the US government will be concerning photovoltaic markets and their development. What role the government will play in the development is not always clear. A lack of a clear long-term government policy may seriously restrict the investment process.

To combat market risk, government actions should be directed at stimulating market growth at the user level. In addition, the actions should attempt to properly identify information about a given future market so that a prospective company can base their investment decision on as much quantitative information as is possible. The development of solid long-term commercial markets can be more

effective than the development of short-term artificial government markets. The market risks associated with proper market identification can only be reduced by market studies, field interviews, and firsthand knowledge concerning the market.

ATTITUDE TOWARD GOVERNMENT PRESENCE

The presence of the government in the development of markets, the support of technology, the dissemination of information, and the other areas of the industrialization process can be viewed by prospective investors in both a positive and negative fashion. There are firms that refuse to participate in any markets that are heavily influenced, controlled, or regulated by government agencies. Their basic fear is they will lose control of their own destiny. It is the fear of losing their flexibility to react to competition and changing market conditions that will restrict their investment in the photovoltaic venture.

Additionally, there is the fear of losing proprietary information. The acceptance of a government contract very often is associated with the relinquishing of control of any information, data, or equipment that may be developed. To some companies, this is not worth the momentary profits that could be made from the project and the significance of the good will associated with making such technological breakthroughs is not considered sufficiently important.

The perspective that a company places upon the loss of proprietary rights depends upon whether they feel technology or marketing expertise will best maintain a leadership role for them in the photovoltaic venture. If technology is considered the foundation for their leadership position, then they will be reluctant to enter into dealings with the government that may ultimately result in a loss of their proprietary technology information. Conversely, if a company feels that it is the product design and marketing of that product that is going to be ultimately important, then the loss of proprietary technology information may not be considered a restriction.

The long-term position of the government within the photovoltaic venture can have a significant influece upon a company. The fear is that a company will invest in the photovoltaic venture based upon certain government regulations, purchases, and environmental control conditions and then suddenly find that the government has either substantially changed its position, or has entirely withdrawn from support of the photovoltaic industry. This could bring financial disaster to the investing company. It is felt in many cases that it is too early in the industrialization process to know the true long-term position of the government in this area. Consequently, investments are being withheld until confidence can be gained in what the government position will ultimately become.

Industry prefers to work with known entities. The selection of even an inadequate or bad policy position in photovoltaics can be dealt with by industry. An unknown government position, however, cannot be dealt with on a constructive basis. Thus a poor government position can be worse than an unknown government position in the viewpoint of industry. It is important, then, for the government position and regulations to be solidified as early as possible.

The presence of the government in the photovoltaic venture can act as an extremely positive influence upon investments. This is especially true for companies that have over the years had a good realtionship with the government. Companies that have dealt in a positive fashion in several areas with the government will be more likely to invest in an area of potential high government involvement. Conversely, negative past experience with the government can act as a restrictive force in inducing potential investors into the photovoltaic venture.

COMPETITIVE ENVIRONMENT

The evaluation of a competitor's strengths and weaknesses can also influence the investment decision. If the competition is viewed to have a strong technological base or market position, then a potential investing company must find some method by which they can counteract these forces if the investment is to move forward. However, if the competition is viewed to be weak in most areas, then a potential company may decide to move rapidly into the photovoltaic venture.

At this point, there are several formidable competitors, but no one has a complete lock upon the market. The market is still in an unstable condition with the leadership role shifting each year from one company to another. The share of market for each company is also changing. As long as an unstable market condition exists, there will always be opportunities for new companies in the photovoltaic venture.

The investment for a new company in photovoltaics will take several different forms, depending on where their competitors' strengths lie. There will be a tendency not to invade a competitor's major area of strength. Consequently, new companies being formed will base their investment upon selected market areas in which to become dominant participators. Future investors will have fewer degrees of freedom in selecting those markets to be serviced, as they will have to account for those companies that are already in the photovoltaic venture.

New companies entering will have to consider what their unique strength is over their competitors, especially if direct head-to-head competition in a given marketplace is contemplated. Even if future companies enter the photovoltaic venture in areas in which there is little or no competition, they will still have to consider what resources they must bring together to remain a dominant or effective competitor in those selected market areas. They cannot expect to continue to exist in a given market area without attracting other competitors, especially if the growth opportunities are significant.

In general terms, it will be difficult to implement any government action that will not disturb the competitive environment in most marketplaces in some fashion. Policies and actions should therefore be developed to indicate market conditions and requirements for effective penetration, but they must be careful not to divulge competitor strengths, weaknesses, capabilities, client relationships, and other proprietary company information. Most government actions will have a tendency to reduce the competitive gap between the stronger and weaker companies.

INSTITUTIONAL ISSUES

There are many noneconomic issues that could restrict the development of certain market segments. Examples of such issues would be:

- Planning cycles within given market areas
- Government regulations
- Transfer of technology
- Tradition
- Local government restrictions
- Environmental restrictions
- Building codes
- Insurance coverage

As discussed in the investment proposal processes and the final decision environment, these can often emerge as the dominant issues in the decision to invest in the photovoltaic venture. Quantitative data showing marginal return on investment can be overriden by the uncertainties associated with these institutional issues.

Low-cost, efficient, properly deployed photovoltaic products may still not penetrate a given market area if the concepts of this new technology cannot be envisioned or accepted by the dominant potential users in the market. Tradition in given marketplaces could play an extremely restrictive role in the development and penetration of photovoltaics. In those areas, it will require more than cost-effectiveness to penetrate the market.

Other markets may still be restricted in their acceptance of photovoltaics due to the extremely long planning cycles required before a new innovation can be implemented. The electric utility industry is an excellent example in the domestic market. Certain planning cycles, procedures, approvals, and governmental requirements must be met before any innovative idea or concept can be implemented. If there were a sudden availability of low-cost photovoltaic products, it would still require a five- to ten-year development period before significant penetration of the electric utility industry were possible.

Rural electrification in developing countries is also characterized by long planning cycles. Rural electrification will result only after it has become recognized as being needed for political reasons. It will then be incorporated in the long-range development plan. The penetration of photovoltaics in these applications will require several years of planning and preparation before actual sale of any significant quantities can be accomplished, even if price and availability are greatly enhanced over near-term prospects.

The objective of any government policies and actions to reduce this barrier would be to disseminate all of the necessary information concerning the institutional or noneconomic issues involved in each of the given future markets. To obtain such information may not be possible through strictly market studies. It may require the installation of an experimental photovoltaic power system. Once these issues are known and understood, American industry can develop compatible programs.

BALANCE OF SYSTEM COSTS

A barrier to the investment in the photovoltaic venture is the fear that some other system component may ultimately restrict the high-growth opportunities. A prime example of this would be the energy storage system, primarily in the area of the storage battery. Other potential areas of high-cost components are in power conditioning, structural material, installation costs, and interconnect material. These elements do not present as optimistic a future for cost reductions as does the photovoltaic module itself. Consequently, penetration of photovoltaic-powered equipment may find restrictions due to these other elements.

The development of government actions and plans should thus incorporate aggressive cost reduction programs in the balance of the cost of the system components. At some point, a significant reduction in the cost of the photovoltaic content of the system may not result in any significant reduction in the overall systems cost. It will be the photovoltaic system that must compete against other systems in the marketplace, not just the photovoltaic portion of the system.

There must be a coordination of efforts between these other component cost reduction programs and those of the photovoltaic program such that the most optimum system cost is developed. There are, for example, present government programs devoted to the development of low-cost batteries. However, they are not being coordinated with the photovoltaic program; in fact, the objective is to develop batteries for load-leveling and electric vehicle industries rather than the photovoltaic industry. While there may be side benefits to the photovoltaic program, there is no guarantee that the technological breakthroughs and products being developed under this other government program will be directly applicable to photovoltaic applications. The same would apply to power conditioning and other component areas that will be supported in the future by government development programs.

4. Effect of Governmernment Actions

4.1 OBJECTIVES

NEED TO DEFINE PROPER ROLE OF GOVERNMENT

The national photovoltaic program has as part of its central theme the rapid development of not only markets but also the implementation of low-cost photovoltaic manufacturing processes. Under normal market conditions, it is not uncommon for a newly formed industry to require from 15 to 25 years for full and mature development. This is true even in the high technology areas where there is a high degree of innovativeness and entrepreneurial activities occurring.

SEMICONDUCTOR INDUSTRY SLOW TO DEVELOP The semiconductor industry began to serve commercial markets in the mid-1950s. The integrated circuit development work in the late 1950s and early 1960s did not result in a full blossoming of a large number of companies until the mid- to late 1960s. In addition, the major portion of all semiconductor products even by 1970 were consumed by only two major market areas: military applications and the computer industry.

The economic downturn of the early 1970s caused many semiconductor companies tremendous financial strain. Several companies ceased operations. Others had to relinquish significant portions of their holdings, and others were completely absorbed by larger corporations. Only during the 1970s has the base for the semiconductor industry been expanding into many different market areas, including consumer electronics, industrial controls, office equipment, instrumentation, communications, automotive products, and a host of other basic markets. It thus took from the mid-1950s to the early to mid-1970s to have semiconductor products consumed in a wide variety of markets.

OBJECTIVE IS TO ACCELERATE INDUSTRIALIZATION A principal objective of the national photovoltaic program is the rapid acceleration of the industrialization process for the photovoltaic venture. It is hoped that through positive government actions, programs, and policies the 15- to 25-year development period can be reduced significantly. It is thus important that the proper role of the government be identified at the earliest stage of development of the photovoltaic venture.

4.2 INFLUENCE OF GOVERNMENT INVOLVEMENT ON NORMAL MARKET CONDITIONS

UNDERLYING CRITERIA FOR ACTION SELECTION

The stated government policy is that any selected actions are to supplement rather than overpower or bypass the basic market forces in the free enterprise system. Normal market environment conditions are to prevail as much as possible during the industrialization of the photovoltaic venture. The objective is then to enhance these normal conditions and foster a more rapid development of the natural evolution of the photovoltaic venture.

CONDITIONS CONSTANTLY CHANGING With this boundary condition, the question arises as to what are the best areas for the government involvement that will least disturb normal market conditions but yet accelerate the industrialization process. There will be an ever-evolving number of opportunities for government actions. Flexibility and timely offering of incentive packages will be critical. The government actions must change as the market conditions and the technology developments change. What is needed in the early stages of the industrialization process may have no effect or may even be detrimental in the intermediate to latter stages. They must lead these changing conditions, however, if they are to continually assist in accelerating the industrialization process. This requires the government policy and program developers to be aware of and in touch with various companies, their needs, their involvement with photovoltaics, and in general provide an atmosphere of trust and partnership.

CRITERIA BASED ON DESIRE FOR EFFICIENT USE OF DOLLARS AND INDUSTRIAL EXPERIENCE Reasons for applying this underlying criteria of not wanting to overpower normal market forces include:

- A more efficient use of the taxpayers' dollars. In effect, this is a cost-sharing approach. The government could finance the entire operation, establishing government-owned and -operated facilities and supplying the product at a sufficiently low price as to cause a high demand for the product. However, the cost to the taxpayer would be tremendous. Through the involvement of the US industrial complex, many of the expenses that will be required to develop the photovoltaic venture will be supplied by industry.

- Through the involvement of the American industrial complex, the creativity and ingenuity of the American free enterprise system will be brought to bear upon the development of the photovoltaic venture. This aspect of the American culture may not have an opportunity to operate in an efficient manner if the entire cost of the project was completely or totally controlled by the government agencies.

It is hoped that through this approach to the industrialization function that the benefits of financial and technical resources, along with proven and experienced business practices, can best develop the photovoltaic venture.

SPECTRUM OF POTENTIAL AREAS OF INVOLVEMENT

Within the photovoltaic industry hierarchy, there are a tremendous number of opportunities for government involvement. The spectrum of potential areas ranges from the research and development subsidies through government-furnished equipment and into market stimulation and generation, with many intermediate options. The major areas of the photovoltaic industry hierarchy are shown in Figure 4.1. In addition are shown the principal areas in which government policies and programs can be applied to stimulate the industrialization process.

The areas in which policies can best be applied would be:

- Market stimulation
- Product development
- Technology advancement

Areas that are best stimulated through various government programs and financing methods would be:

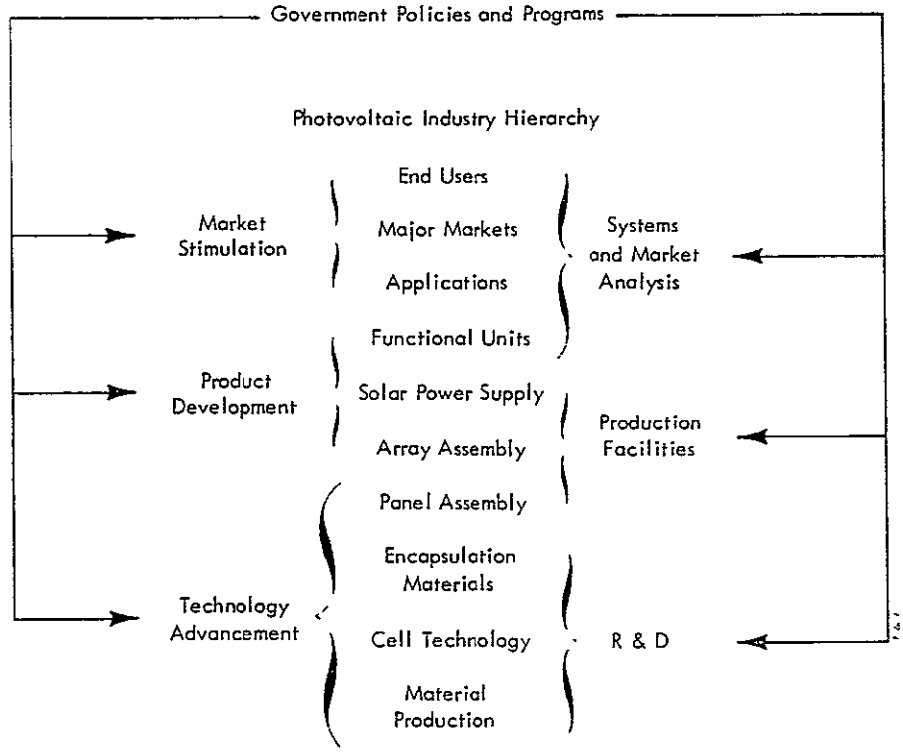
- System and market analysis
- Production facilities
- Research and development

Both policies and programs can act as a stimulation or incentive to the development of each layer of the photovoltaic industry hierarchy. Whether a policy or a financial program is applied to a given area depends on the results that are desired.

To be the most effective, it will require a coordinated effort between the establishment of proper policies and the implementation of programs. For instance, it may be that in certain applications within major markets, an experimental system must be established through some financial program to determine the major characteristics

FIGURE 4.1

SPECTRUM OF POTENTIAL AREAS
OF
GOVERNMENT INVOLVEMENT



of not only the system and the application, but also the market conditions. Once the experiment has yielded its information, it should then be followed by the proper policy that would encourage the end-user to demand the use of photovoltaics in that particular application.

Such a policy may take the form of a tax preference or tax credit, depending on the special conditions within that marketplace. The application, however, of first the policy and then the experimental system may result in an inefficient use of dollars and run the chance of establishing the wrong policy.

In general, the financial programs will require the expenditure of monies early in the developmental cycle and in a very direct and dedicated fashion. The establishment of policies will not necessarily require the expenditure of monies directly but it will in many cases result in a cost to the government in the form of reduced revenues collected through the tax system. These lost revenues can be considered expenditures on the part of the government, but they may be difficult or impossible to identify and associate specifically with the photovoltaic industrialization program.

While there are many opportunities within the photovoltaic industry hierarchy for government involvement, it is not necessarily beneficial to have a government program or policy established for every opportunity. Some areas may best be accomplished through the normal procedures and methods of doing business that are already established within the US industrial complex. It must be remembered that the objective of the government role is to stimulate and enhance the industrialization process, not to dominate or overwhelm industry capabilities. There are certain areas that may best be left to the ingenuity and creativity of American industrialists.

4.3 GOVERNMENT INCENTIVES TO INVESTMENT

COMMENTARY ON REACTION TO GOVERNMENT INCENTIVES

There are many incentives that the government can use to induce industry into investment areas. Each of these incentives can also have a large number of variations such that their design can meet the special needs of each participating company. Extreme care must be taken, however, in their design in that they can easily bias the direction in which the market develops and selectively enhance and discourage specific companies.

DIRECT GOVERNMENT INCENTIVES AT FUNDAMENTAL BARRIERS In any venture, it is easy to identify those companies that would appear to be the most logical to participate in that venture, and it is also easy to design policies and programs around those companies. Through such policy designs, these companies become heavily involved in the venture. It appears as though the policies were properly designed and attracted the proper companies. However, if the incentive package had been designed to reduce barriers to investments, then it may have been found that a broader spectrum of companies could have become involved in the venture.

It is thus critical and important that the government incentives be developed. In relationship to the photovoltaic venture, the most obvious companies to be involved would be the semiconductor-based companies. The technology for the photovoltaic venture is based upon the same technology and manufacturing techniques that have made the semiconductor venture so successful in this country. But as discussed in earlier sections, the semiconductor industry has associated with it many deficits that will have to be overcome in some fashion to meet all of the requirements of the future photovoltaic industry.

There are other industry-type companies that have far greater assets available to be devoted to the photovoltaic venture than do the semiconductor companies. Even within those companies, there are some serious deficits which must be overcome. In order for the government not to bias the market toward the semiconductor industry or retard or eliminate some valuable resources in other companies, the government incentive packages must be carefully designed and directed at fundamental barriers to investments across the entire US industrial complex. They should not be directed at the removal of specific barriers associated with specific companies.

COMPROMISING OF RESTRICTIONS REQUIRED Preparing incentives not to bias the market and at the same time meet other boundary conditions, such as fostering small business or not overpowering normal market driving forces and competitive influences, will be virtually impossible. A compromise of all of these aspects is the best that can be accomplished.

MIXED REACTIONS WILL OCCUR TO ANY GOVERNMENT INCENTIVE An incentive designed at reducing investment barriers will be received differently by different companies, even within a similar industrial grouping. Each company has its own particular requirements and viewpoints of the height of the barriers to the investment. Two companies within the same industrial grouping with the same barriers will react differently to the same incentive package because the barriers to investment will be perceived differently. The difference in perspective of each of the investment barriers will vary due to differences in management style and philosophy, the available resources, their relationship to the government, previous investments, and investments that are competing for the resources of the company.

Because of the rate of return on present investments and availability of cash and credit, the cost of money will vary from one company to another. A high capital-intensive investment such as photovoltaics could be seriously influenced by the cost of money. This alone may make the photovoltaic venture appear attractive to one company and not attractive to another, even within the same industrial grouping.

To meet the wide variability that exists within the American industrial complex, a group of incentives will have to be developed. No one or two incentive packages will accomplish the goals of the industrialization project. Not only will several parallel incentives have to be implemented, but there will also have to be a sequential application of incentives to account for the ever-changing conditions that will face prospective and present investors.

NEGATIVE ACTIONS SHOULD BE AVOIDED There are also negative government actions that can bias the market away from certain types of companies and toward others. This could discourage investments from some of the better-equipped companies. Such a negative action would be that of imposing restrictions on the participation of petrochemical-based firms within the photovoltaic venture, or not recognizing other nonsemiconductor-based companies would be seriously interested in the photovoltaic venture. Such companies would be those associated with thin-film technologies, equipment manufacturers, controls companies, glass and lead producers, and a host of other industrial firms.

Other negative actions that must be guarded against are the implementation of legislation that dictates performance versus cost criteria. This is an area that should be left to the ingenuity and responsibility of private industry. Legislation must be implemented, however, to protect the public, but it should not dictate product design or performance criteria. It should, however, determine standards of how performance can be measured and should include certain minimum aspects, such as building code requirements and safety aspects. Once the pursuit of performance versus cost criteria is evident, then industrial concerns will begin to lose interest in the venture, as they will feel they have lost control of their own destiny.

LONG-TERM GOVERNMENT COMMITMENT NEEDED Since the photovoltaic venture is a long-range venture, then it would be detrimental to the acceleration of the industrialization process for the government to pursue programs and policies based on only one-year commitments. Multiple-year commitments must be established in all incentive packages. Government commitments on a one-year basis do not allow for the gaining of confidence on the part of industrial companies that the government will be supportive of the photovoltaic venture in the following years. There must be longer-term commitments on the part of the government if long-term commitments are expected from industry, especially if the government's objective is to cause investments to occur sooner than they would normally. Thus, an excellent incentive package based on too short a time span will be far less effective.

A V A I L A B L E I N C E N T I V E S

SUBSIDIZE PHOTOVOLTAIC RESEARCH AND DEVELOPMENT

The subsidizing of research and development activities would cover a significant portion of expenses of industrial firms associated with the labor, material, and equipment involved in the development of various phases of the photovoltaic technology. These investigations and development areas would include:

- Solar cell material development such as silicon, gallium arsenide, cadmium sulfide, and other basic materials
- Encapsulation material investigations. This would include substrates, superstrates, fillers, sealants, and other needed packaging materials.

- Solar cell device technology. This would include technologies and manufacturing techniques associated with the production of the actual solar cell device such as diffusion, metallization, interconnect, ion implant, low-cost silicon sheets, and a wide variety of device structure investigations.

- Module assembly. This area would include the automation technologies and investigations of low-cost assembly techniques required to bring the encapsulation material and solar cell devices to a completed functional module.

The concept of subsidizing photovoltaic research and development activities could also be expanded to include the activities associated with the functional systems. An additional expansion of the concept could also include the remaining components within a photovoltaic power supply, such as batteries, construction, and interconnect materials. For the purposes of this report, these extensions of the concept have not been considered. Subsidizing photovoltaic research and development has been limited to those items associated with the photovoltaic module itself.

SUBSIDIZE PRICES

Incentives designed to subsidize prices would be in the form of payments to photovoltaic suppliers from federal funds to account for the difference between the supplier's selling price and the price that the market is willing to pay. The prevailing market price would probably be established as that which exists for presently established energy sources. The supplier's price would have to be based upon industry average selling prices or some arbitrarily selected price by the federal government. Another form would be a fixed amount of money per peak watt shipped paid to the supplier from government funds. The dollars per peak watt would be on a declining basis in association with either accumulated volume or time, regardless of what markets were being served. Subsidized prices would be applied early in the photovoltaic venture.

GUARANTEE MARKET

A guaranteed market incentive would be based on the government continuing to purchase increasing volumes of photovoltaic products each year but at declining prices. This would continue until it was determined that manufacturing costs were sufficiently low to supply products in the commercial marketplace at competitive prices. Depending upon the volume required, the government-purchased products would first be directed at governnment applications and secondly to commercial applications.

EXPERIMENTAL AND DEMONSTRATION PROJECTS

The experimental and demonstration projects would be directed at noncommercially served future photovoltaic markets. The intent would be the establishment of a working field experimental model of a photovoltaic-powered functional system. These experiments may not necessarily be economically feasible within that market, but they would be designed to highlight system problems and institutional issues. Field demonstration projects would be directed at demonstrating technical and economic viability. There would obviously be many experimental projects within a given market before demonstration projects were implemented. The emphasis would be upon the system first and the economics second.

MARKET STUDIES

Market studies would be directed at the proper identification of markets and their characterization. This would include not only the applications but the economics involved in the competing energy sources, the basic driving forces behind that particular application, institutional problems associated with penetration, and product requirements.

GOVERNMENT-FURNISHED EQUIPMENT

The government-furnished equipment (GFE) approach is well established within the military and aerospace industries. It could include in its simplest form the grant of funds to a company for an experimental piece of equipment. The construction of a building, a complete production facility, and equipment would represent the more elaborate form of GFE. These facilities and equipment would be under the direction of specific companies for manning and operation. The companies would use these resources strictly for the photovoltaic venture. However, the companies would pay all expenses involved for labor, consumables, management, and alterations.

MANAGEMENT FEE

A management fee is an addition to the GFE approach. Here the expense associated with the operation of a facility, usually the overhead portion, is paid to a company through a management fee. Management fees are seldom if ever used independent of a GFE facility. For the purposes of this report, it will be assumed that a management fee is associated with a GFE project.

PRODUCTION DEMONSTRATION

A production demonstration program provides a small-scale or pilot production facility, implemented with government funding to demonstrate not only the technology involved, but the financial viability of the project. The pilot line itself may not be completely economical, but it will produce the necessary data and information to demonstrate the economic viability at certain minimum or integral steps. These production facilities are assumed to be under the management of some industrial concern. In effect, they are privately operated rather than government-operated.

END-USER FINANCIAL ASSISTANCE

Incentives directed at the end-user to assist in justifying or rationalizing the purchase of photovoltaic products could include direct cash rebates on a per-watt basis of installed capacity or may occur in the form of tax credits. Tax credits assume some tax liability. For certain companies, this would be a significant incentive. For the residential homeowner, a tax credit could be a significant influence, as would a direct rebate on a per-watt basis. This incentive would be applied only in areas where the difference in selling price and that which the market is willing to pay is relatively small (no more than a factor of 2). This would imply application late in the development of the venture.

SUPPLIER TAX PREFERENCE

A supplier tax preference incentive assumes the supplier will have some tax liability to which he can apply a tax credit. For a newly formed photovoltaic company, it may be several years before such tax credits could be used to their advantage. However, large corporations with multiple areas of investments in which profits are being realized could use a tax incentive immediately upon the investment in photovoltaics. An additional supplier tax preference could be based upon a more rapid acceleration of depreciation for investments made in the photovoltaic area. This would give greater incentives to newly formed companies as well as the larger, broader-based corporations.

LOAN GUARANTEES TO PHOTOVOLTAIC INVESTORS

A loan guarantee package would provide assurances to financial resources that repayment of monies invested in photovoltaics would be guaranteed by the government. Their benefits would be directed toward those companies that would have difficulty obtaining funds if

it were so decided to enter the photovoltaic industry. If financial funds are available to a prospective company, then loan guarantees would have little relevance.

Loan guarantees could be directed at end-users to finance the installation of photovoltaic products. Again, if availability of funds were sufficient, then loan guarantees would have no relevance. If, however, obtaining funds would be a significant limitation, then loan guarantees may possibly have some significant influence in the end-user area.

4.4 EFFECT OF GOVERNMENT ACTION ON PERCEIVED BARRIERS

MATRIX OF BARRIERS AND INCENTIVES

The perceived barriers to the photovoltaic investment were discussed in Section 3.7. A brief listing of the available incentives were listed in Section 4.3. A matrix of these perceived barriers and the available government incentives is shown in Table 4.1.

In each cell of the matrix is an indication of the expected effect of a given government incentive on a perceived barrier. The degree of the effect is depicted with the following notation:

I^+	Significantly increases barrier
I	Increases barrier
0	No effect
D	Decreases barrier
D^-	Significantly decreases
*	Limited duration or under certain specific assumptions

The notations within the table are from the perspective of a potential investor in photovoltaics. This is to be distinguished from an investor who has already made the commitment to the photovoltaic venture. Only in a few instances will this distinction make any significant difference. The descriptions of the various cells that follow will denote if this difference is significant.

The government incentives have been divided into two major areas: programs and policies. The distinction is that programs are associated with fundings that are identifiable and represent direct support of the photovoltaic industry. Policies represent an indirect support of the photovoltaic venture, and it may not be possible to identify specifically those dollars involved with supporting the policies. Tax credits, for instance, may be difficult to identify directly with the photovoltaic venture, but they do represent government funding, in that at some future date there will be a reduction in collected tax revenues.

TABLE 4.1
IMPACT OF VARIOUS CURRENT GOVERNMENT PROGRAMS ON MAJOR PERCEIVED AREAS OF RISK

Area of Current Government Programs	Rapid Technological Advancement	Technical/Field Demonstrations and Experiments	Market Characterization Studies	Direct Purchase of Photovoltaic Products	Production Demonstrations
Representative Government Program	JPL-LSA Project Tasks I-IV	NASA Lewis, Sandia, MIT, and MERADCOM field demonstrations	BDM and ITC market studies	JPL, Sandia, and former ERDA purchases	JPL Program in silicon, LSA project
Perceived Areas of Risk					
Financial risk	Increases	Slightly decreases, insiders tend to benefit more than outsiders	Slight decrease, not as effective as possible	No notable influence	Slight decrease possible, but excludes outsiders
Market Risk					
Proper identification	No effect	Decreases	Decreases, but well below max potential	No effect	No effect
Penetration	Slight to significant decrease	Decreases	No effect or slight decrease	No effect or only slight decrease	No effect
Technological Risk					
Basic knowledge of photovoltaics	Significant decrease	Decreases	No effect	No effect	Potential decrease
Obsolescence of proposed investment	Significant increase	No effect	No effect	Slight decrease	Potential decrease
System requirements	No effect	Significant decrease	Slight decrease	No effect	No effect

H I G H L I G H T S

PRODUCTS AND MARKETS NOT COMPATIBLE

The first significant point to be noted is that the absolute barrier associated with a company's product not being compatible with photovoltaic requirements is not significantly influenced by any available government incentives. The point being that if a company is too diverse from the photovoltaic venture and has no interest in diversification into photovoltaics, then there is very little the government can do.

There are options available to the government to force a company into the photovoltaic venture. This would, however, be in violation of the underlying criteria that the industrialization process disturb as little as possible the normal influences at work in the marketplace.

Even companies with a significant tie to the photovoltaic industry through their technology base may still not decide to invest. If the products and markets are considered too diverse from their basic areas of endeavor, it would be difficult to induce even those companies into the photovoltaic venture.

LOW FINANCIAL REWARD

The greatest effects on the perceived barrier of low financial reward come from the subsidizing of photovoltaic research and development efforts and supplier tax preferences. The low financial reward perceived in the photovoltaic venture can only be overcome by either reducing the investment on which the rewards are based, or increasing the expected revenues.

Expenditures for equipment and other investments in research and development areas represent a significant portion of the investment base upon which the reward is measured. Through R&D subsidies and supplier tax preferences such as accelerated depreciation of photovoltaic equipment, the barrier of low perceived financial reward can be substantially reduced.. There are other areas and methods also by which this barrier can be reduced. They include the government-furnished equipment or the management fee incentives. These would reduce the base upon which rewards are measured.

Production demonstrations offer the possibility of a reduction in the perceived low financial reward barrier, in that they may demonstrate a production method that has lower costs or investments than were originally used in calculating the expected rewards. Considering the long development time associated with production demonstrations, it is unlikely that a proposed venture would be influenced significantly in the near term by such an incentive. Companies considering an investment venture would be well aware of the timing of such production demonstrations and would use the latest available information in their financial calculations. They would therefore not be surprised by any findings from such production demonstrations. It could, however, delay a potential company from investing in a photovoltaic venture if they were waiting for the results of a production demonstration before investing.

There are two other areas that may cause a reduction in the low financial reward barrier. They would be the field experiments and demonstration projects, and end-user financial assistance. Here the reasoning is that these two areas of incentives could cause an earlier development of a given market compared to what was expected. Since future revenues are usually considered on a discounted basis, then an earlier arrival of such revenues would have an increased value in the financial calculations.

It has been assumed that the subsidizing of prices or the guaranteeing of markets would be at fair market levels. Under such assumptions, these two incentives would have little effect upon the calculated rewards in a photovoltaic venture. If prices were guaranteed significantly above their fair market level, or that sufficiently large markets were being guaranteed, then a possible significant influence could be expected on the perceived rewards. However, such conditions would significantly violate the underlying criteria that normal market conditions are to prevail as much as possible.

Loan guarantees to investing firms were found to have little influencing effect upon the perceived financial rewards. Apparently companies considering the photovoltaic venture have financial resources available to them, either from internal investments or from credit relationships with financial institutions. Availability of funds only becomes a problem with small business. However, even for a small business venture, a loan guarantee only provides the funds; it does not substantially change any of the investments required or the revenues expected. Thus it will have little if any effect upon the perceived financial rewards available within the photovoltaic venture. Having unlimited financial resources available will not in most cases induce a company to enter what is perceived to be a low financial reward venture.

MARKET RISKS

The perceived barriers associated with market risks are influenced the most by market studies and field experiments and demonstration projects. The proper identification of markets is best accomplished through properly designed market studies. None of the other incentives offer as significant an opportunity for reducing market risks associated with proper market identification as does a properly constructed market study. In fact, other incentives provide no information whatsoever about potential markets. Field experiments and demonstrations can add insights into market characterizations. It will be somewhat limited, however.

In the area of penetrating identified markets, the most effective incentive is the end-user financial assistance, which comes in the form of either tax credits or direct rebates on a per-watt installed basis. Limited insights can possibly be gained from market studies and field demonstration projects in how to penetrate markets.

A supplier tax preference can have some influence on penetration in that it allows a cost reduction in the product to occur which in turn should result in a corresponding increase in penetration within a given market. This assumes, however, that the threshold of

economic viability has already been reached. If it is significantly below the price of the product, then even a supplier tax preference may not allow a sufficient reduction in cost to provide a reduced price in the products to enhance further penetration.

There is a case for subsidizing prices in that it will also allow the supplier to reduce the price of his product, hopefully below the economic viability threshold. The size of the subsidy, however, may become so large that it would not allow for an efficient use of tax dollars. It would only be effective where a marginal difference between supplier prices and economic viability exists.

The subsidizing of photovoltaic research and development could cause a significant increase in penetration to occur. This is based on the assumption that an advancement in research and development would allow a significant cost reduction in the product, thus allowing a corresponding penetration increase.

In summary, the market risks are reduced primarily through market studies and end-user financial assistance. Other selected incentives will have a positive influence, but to a lesser degree.

TECHNOLOGY RISKS

There is a tremendous variation in the effect of government incentives on the barriers associated with technology risk. A given incentive may have both positive and negative effects within the technological risk spectrum. The principal concern in the technological area to an investing company is the obsolescence of their proposed investment before they are able to obtain a reasonable financial reward.

The subsidizing of photovoltaic research and development activities represents a significant negative influence on this obsolescence barrier. Through subsidizing research and development activities that produce rapid technological advancements, the risks are increased that some new technology will be devised that will obsolete present-day established technological bases. An investment in present-day technology could very easily be obsoleted long before a financial reward could be obtained. Any advancements thus brought through R&D subsidies may actually act as an increase to the barriers to inducing other companies to invest or at least act as a delaying factor in considering the photovoltaic venture.

There are other incentives, however, that can produce a reduction in the barrier associated with obsolescence. These would include the subsidizing of prices and the guaranteeing of at least

minimum market levels. Through these programs, the investment could be recouped. Such programs tend, however, to cause costs and prices to remain at higher levels than would otherwise be expected. If the market is guaranteed, then there is little incentive to reduce costs and become more competitive. The same is true if prices are to be subsidized.

An incentive that tends to delay the obsolescence of an investment is the GFE approach. The effective investment is significantly reduced through the GFE approach, therefore requiring less time to recoup the investment. The GFE and management fee route, however, is only effective for a limited time, especially if through research and development activities a new low-cost process or manufacturing procedure is developed.

The other disadvantage of the GFE and management incentive is that it tends to freeze technology and discourages further development. Through the installation of significant-sized GFE facilities, the manufacturing techniques and the dominant technologies are frozen, thus allowing only minimal reductions in prices through the accumulated volume concept.

Production demonstrations offer a possibility of decreasing the obsolescence barrier in that they demonstrate that certain technologies can effectively and at some price level produce photovoltaic products or components.

The risks associated with unknown systems requirements can only be effectively reduced through field experiments and demonstration projects. This method offers significant possibilities for identifying many systems-related problems that would not otherwise be detectable in a laboratory or through a paper study of the system.

There is the possibility that the concept of a subsidized photovoltaic research and development program could be expanded to include laboratory evaluations of systems. This might offer some possibility of decreasing risks associated wih systems requirements. None of the other listed government incentive packages offer little if any possibility of reducing the risks associated with this barrier.

ATTITUDE TOWARD GOVERNMENT PRESENCE

The presence of the government in a given area of development or market can be looked upon in various fashions by a company. It is interesting to note that one division of a company may view the government presence as an asset, while another division may view government presence as a deficit. There are companies that have considered the photovoltaic venture and dismissed it as a viable

venture in some of their commercial-based divisions, and yet have found it to be a venture worth consideration within their government electronics or aerospace divisions. Viability refers to either an investment in the photovoltaic venture on a commercial basis or the continued development of research and development activities with the future potential of developing a commercial product.

In general, the establishment of government programs is viewed to have a negative effect in that they tend to increase the barrier to investments. Policies, on the other hand, are not viewed in a negative fashion. In fact, policies tend to reduce the barriers.

Government presence is considered to be a barrier in that it causes a company to lose control of its own destiny or causes the dissemination of what might otherwise be proprietary technological information. The government programs tend to affect internal affairs of the company. Policies, by contrast, tend to affect market development aspects which are external to the company's immediate affairs and controllability.

The most damaging government incentives to the barrier of government presence is government-furnished equipment, management fees, and production demonstrations. For those companies that do not wish to have government interference with development activities, these three areas hit the hardest at destroying their incentive to invest in a given venture. They, in effect, put weaker competitors on an equal footing with what would otherwise be a strong competitor.

A similar influence is resultant from government subsidizing photovoltaic research and development projects. Again, this is viewed as an invasion of a company's potential proprietary technological position or domain. Quite often companies will refuse to participate in government-subsidized R&D programs because of the requirement for the general dissemination of all pertinent information that is derived. In addition, it may even result in the dissemination of proprietary information in other areas that may have been used as a basis upon which the new R&D information was derived.

Subsidizing prices and guaranteeing minimum market levels are also considered to have a negative influence upon this investment barrier. These incentives tend to distort or overrule normal market conditions. To take advantage of such incentives often has associated with it many government restrictions and regulations, including significant paper work to justify prices and levels of involvement. Thus these incentives, while affecting the market which would normally be considered an external involvement as discussed in connection with policies, have serious ramifications internal to the company. These ramifications are interpreted as risk areas, even though there may be some prospective revenues associated with them.

The most effective government incentives to overcome the barrier of attitude toward government presence is in the area of policies, primarily that of implementing end-user financial assistance and providing supplier tax preferences. End-user financial assistance tends to significantly influence an increase in market demand. Supplier tax preferences allow a reduction in the cost of producing the products and translates into an increased ability to penetrate markets. This ability to penetrate markets may not actually occur, but the prospect of being able to write off equipment early or reduce the tax liability of the company tends to act as a reduction on the perceived barrier.

COMPETITIVE ENVIRONMENT

The barrier of competitive environment is reduced by almost all government incentives. The primary reason is that most government incentives tend to put all competitors on an equal basis. Thus a company considering entering a high-risk and high-capital-intensive investment such as the photovoltaic venture would want as many advantages given to them through government programs and policies as possible to enhance their position at the time of entrance.

It is interesting to note, however, that once a company has become significantly entrenched within the venture, their viewpoint of many of these incentives begins to change to that held by companies who consider government presence to be a barrier. In other words, once they have established themselves, they prefer government incentives not to be implemented for the encouragement of further competitors entering the marketplace. Government incentives tend to favor the weaker companies and restrict the stronger competitors.

The competitive environment barrier acts as a screen that discourages weak or nonqualified companies from entering a venture. If the competitive barrier is reduced significantly, then there will be a tendency for a larger number of companies to invest. In general, they will be the smaller companies with fewer resources. A fostering of a large number of small competitors simply dilutes the available government resources and in no way adds to an accumulation of industry experience. However, applying those same resources to a limited number of investors better ensures that each investor has a much larger base of accumulated knowledge, experience, and expertise in advancing the venture.

This could be carried to extremes in which all resources were invested in only one company, such that all experience would then be shared. However, it would destroy the competitive aspect of the free enterprise system and in effect become a totally government-dominated

or at least -regulated industry. A constant watch must be made upon how the industrialization process is proceeding to ensure that a reasonable compromise between competitive environment and the ability to accumulate large quantities of information, technology, experience, and expertise occurs.

INSTITUTIONAL ISSUES

The institutional issues that can act as a barrier to investments can only be effectively reduced through either field experiments and demonstrations or properly designed market studies, with the field experiments and demonstrations having by far the greater effect in resolving problems. The market studies hold the potential of identifying the institutional issues but in no way could offer hard and tried solutions. None of the other available incentives have an effect upon this barrier.

BALANCE OF SYSTEM COSTS

The barrier associated with the balance of systems costs will be a difficult one to overcome through government incentives. Field experiments and demonstration projects can only identify what these other system costs will be and what their effective levels are likely to be. Without some systematic research and development effort directed at the specific components that are causing the system costs to decrease at a much slower rate than desirable, there is little that can be done through government incentives.

The use of end-user financial assistance policies may be one method of reducing the overall cost of the system. If the policy is directed at financial assistance on what the end-user paid for only the photovoltaic panel, then it would have little effect upon the balance of systems cost. If, however, the financial assistance was based upon what was paid for the functional system, then the financial assistance could be applied to reduce whatever component costs are causing the overall systems costs to be out of line.

Supplier tax preference would not have a significant influence upon reducing the balance of systems cost barriers. However, if it could be applied to the suppliers of the other high-cost components within the system, then an effective reduction of this barrier could be obtained. However, the ramifications are significant in this case. For instance, would the tax preference be applied only to components sold into photovoltaic applications, or would it be given in a general fashion regardless of how the components were distributed throughout the marketplace? To make supplier tax preference an effective tool for reducing this barrier, careful study and consideration must first be applied.

GOVERNMENT INCENTIVES AND THEIR EFFECTIVENESS

Of all of the government incentives, the field experimentation and demonstration programs offer the broadest effect across the perceived barriers. It has significant influence in reducing the risks associated with systems requirements and the resolving of institutional issues. It has a noticeable effect upon reducing risks associated with proper market identification and characterization, gathering of basic knowledge in the use and reliablity of photovoltaics, a reduction in the competitive environment barrier, and offers possibilities of identifying and characterizing the balance of systems costs under actual usage conditions.

It also offers some possibility for reducing the perceived low financial rewards and assisting to some extent in enhancing penetration possibilities within certain markets. None of the other government incentives offer as broad a range of effectiveness.

There are a number of other incentives that offer a limited range of effectiveness. These include:

- Market studies
- Supplier tax preferences
- End-user financial assistance
- Subsidizing photovoltaic research and development activities
- Production demonstrations

The remaining incentives listed in Table 4.1 have relatively little, if any, positive influence upon reducing barriers. This would include subsidizing prices, government-funded equipment, management fee, and market guarantees. Loan guarantees seem to have no influence, either positive or negative, in reducing investment barriers.

4.5 RECOMMENDATIONS

RANKING OF GOVERNMENT INCENTIVES

In Section 4.4 was a listing of the government incentives based on their breadth of positive influence. In effect, it was based only upon the number of areas in which a given incentive would have a positive effect. That arrangement was not influenced by the degree of effectiveness upon a given barrier or any emphasis placed upon their effect on major barriers that are more common among a larger number of potential investors in the photovoltaic venture. To add some analytical perspective to this listing, a weighting of influences must be established for the various perceived barriers and the effectiveness that a given incentive has upon that barrier.

An incentive that has a significant positive influence upon reducing a major or predominant perceived barrier would have greater value than when applied against a less dominant perceived barrier. Conversely, an incentive that tends to significantly increase a dominant or common barrier should have a significantly lower value associated with it.

WEIGHTING OF BARRIERS A weighting system is shown in Table 4.2, in which low financial reward, high risk associated with markets, the high risks associated with technological obsolescence, and the institutional issues are considered to be the dominant perceived barriers to the photovoltaic investment and have a higher weighting. The second-order effects are those risks associated with systems requirements and the balance of systems costs. The other perceived barriers are known to exist but do not appear to be the dominant restrictors in an expansion of the photovoltaic venture.

This evaluation of the perceived barriers was based on extensive field interviews with companies both in and outside of the photovoltaic industry. Those companies outside the photovoltaic industry were further subdivided into those considering and those that have already rejected the photovoltaic venture as a viable investment area.

For the more dominant and commonly perceived barriers that restrict the photovoltaic venture from attracting more companies, a weighting factor of three times the normal emphasis has been applied. For the secondary barriers, a weighting factor of two times the normal emphasis has been assigned, and the remaining barriers were assigned a unit value of emphasis. This is an arbitrary scale and is subject to significant judgment. The emphasis here is to segregate by some numerical fashion those barriers that are more predominant in the marketplace from those that, while they do exist, are less dominant or less common.

TABLE 4.2
ASSIGNED WEIGHTING TO BARRIERS AND EFFECTS

Perceived Barriers to Photovoltaic Investment	Weighting
Absolute	
Low financial reward	3X
Not in desired products/markets	1X
Secondary	
High risk--Market	
Proper identification	3X
Penetration	3X
High risk-Technological	
Basic knowledge	1X
Obsolescence of proposed investment	3X
System requirements	2X
Attitude toward government presence	1X
Competitive environment	1X
Institutional issues	3X
Balance of system costs	2X
Effect of Government Incentives	**Weighting**
I^+ Significantly increases barrier	-2
I Increases barrier	-1
0 No effect	0
D Decreases barrier	+1
D^- Significantly decreases barrier	+2
* Only under certain assumptions	0.5 Counter Value

WEIGHTING FACTORS FOR EFFECT OF INCENTIVES The weighting factors assigned to the effectiveness of a given government incentive are also shown in Table 4.2. Here a no-effect incentive received a zero weighting. A positive unit value was assigned to any incentive effect that decreases the investment barrier, and a two-unit value was assigned to any incentive that has a significant decrease on a perceived barrier. Conversely, a negative unit value was assigned to any incentive that tended to increase the perceived barriers, and a negative two units of value were assigned to those incentives that caused significant increases in barriers.

For those cases in which an incentive tends to decrease or increase a barrier only under special conditions, a half unit of counter value was assigned to those cases. For instance, any incentive producing a decrease in the barrier would normally receive a one-unit value. However, because it is only under special conditions or under limited duration, the positive one unit of value was reduced by the 0.5 counter value, resulting in only a 0.5 value assigned to that incentive in relation to that given investment

barrier. When applied toward those areas in which incentives tended to increase the barrier, the 0.5 counter value was used to reduce the effective increase in that perceived barrier.

Again, this is an arbitrary scale subject to judgment and interpretation. It does, however, add some analytical basis upon which a given interaction between an incentive and a perceived barrier can be evaluated.

APPLICATION OF WEIGHTING FACTORS The weighting scale is applied to the results of Table 4.1 in the following fashion. The designated effect was replaced by the weighted value shown in the lower portion of Table 4.2. It was then multiplied by the weighting factor associated with that perceived barrier, as shown in the upper portion of Table 4.2. The application of these weighting factors in each of the individual cells is shown in Table 4.3, along with a summary total for the individual government incentives.

TABLE 4.3
WEIGHTING OF EFFECT OF GOVERNMENT INCENTIVES

	Government Incentives										
	Programs (Identifiable, Direct Support)								Policies (Indirect Support)		
Perceived Barriers to Photovoltaic Investment	Subsidize R&D	Subsidize Prices	Guarantee Market	Demonstrations & Experiments	Market Studies	GFE	Managment Fee	Production Demonstration	End-User Financial Assistance	Supplier Tax Preference	Loan Guarantee
Absolute											
Low financial reward	6	0	0	1.5	0	3	3	1.5	1.5	6	0
Not in desired products/markets	0	0	0	0	0	0	0	0	0	0	0
Secondary											
High Risk--Market Proper identification	0	0	0	3	6	0	0	0	0	0	0
Penetration	1.5	3	0	3	3	0	0	0	6	1 5	0
High Risk--Technological Basic knowledge	2	0	0	1	0	-0.5	-0 5	0.5	0	0	0
Obsolescence of proposed investment	-3	3	3	0	0	1.5	1.5	3	0	0	0
System requirements	0	0	0	4	0	0	0	0	0	0	0
Attitude toward government presence	-1	-1	-1	0	0	-2	-2	-2	2	1	0
Competitive environment	1	1	1	1	1	2	2	1	0	1	0
Institutional issues	0	0	0	6	3	0	0	0	0	0	0
Balance of system costs	0	0	0	2	0	0	0	0	2	2	0
Total of weighting factors	6.5	6 0	3.0	21.5	13.0	4.0	4.0	4.0	11.5	11.5	0

RANKING OF INCENTIVES The summary results of the application of weighting factors is repeated in Table 4.4, along with a ranking of the incentives. The various government incentives are listed according to first their breadth of positive influence, as previously discussed in Section 4.4. The next column shows the ranking of these incentives when all of the weighting factors are applied. The last column ranks the incentives when only secondary barriers are taken into consideration.

TABLE 4.4
RANKING OF GOVERNMENT INCENTIVES

Incentives	Ranking Based On:		
	Breadth of Positive Influence	Weighting of All Barriers and Effects	Weighting of Only Secondary Barriers and Effects
Field experiments/demonstrations	1	1 (21.5)	1 (20.0)
Market studies	2	2 (13.0)	2 (13.0)
Supplier tax preference	2	3 (11.5)	5* (5.5)
End-user financial assistance	2	4 (11.5)	3 (10.0)
Subsidize photovoltaic R&D	2	5 (6.5)	10* (0.5)
Subsidize prices	3	6 (6.0)	4 (6.0)
GFE	3	7 (4.0)	8* (1.0)
Management fee	3	8 (4.0)	9* (1.0)
Production demonstration	2	9 (4.0)	7* (2.5)
Market guarantee	4	10 (3.0)	6 (3.0)
Loan guarantee	5	11 (0)	11 (0)

*Primary influence is on absolute barriers.

Numbers in parentheses are the totals of weighting factors.

This distinction was used to separate those incentives that ultimately received the same numerical results when all of the weighting factors were applied, the idea being that those incentives which had a greater portion of their value associated with absolute barriers were of greater importance than those associated with secondary barriers. Those incentives that were deemed to have a significant portion of their value associated with absolute barriers are marked by an asterisk in the last column.

It is interesting to note that when the numerical weighting factors were applied to the effect of the incentives that no significant shifting of the ranking occurred when compared to the ranking of those incentives based strictly on the breadth of their positive influence. In other words, those incentives with the broadest area of effectiveness generally received the higher numerical value associated with their effectiveness when all barriers were taken into consideration. A more significant shifting of the rankings occurred when the absolute barriers are removed from the ranking process.

SUBSIDIZING RESEARCH AND DEVELOPMENT NOT EFFECTIVE IN INDUCING INVESTMENT Particular note should be made of the ranking of the subsidizing of photovoltaic research and development projects. Its ranking, when considering all barrier types, was number five. However, if only secondary barriers are considered, this incentive drops to the number ten ranking position.

The implication is that except for the fact that such an incentive reduces the required investment, it has little effect upon inducing companies to enter the photovoltaic venture. In fact, the field interviews indicated that the investment in the photovoltaic venture on a commercial basis by all but one company was made independently of considering that the government would in some fashion subsidize at least a portion of a prospective company's research and development activities. In other words, a company's decision to enter the photovoltaic venture was based on other considerations and not the fact that the government is subsidizing research and development.

This does not mean that a company once in the photovoltaic venture will totally ignore the money being made available through government funding of research and development activities, but it does not play a significant role in inducing companies to enter the photovoltaic venture on a commercial basis. Those incentives that tend to develop the markets have the greatest effect upon reducing barriers and inducing companies to enter the marketplace. This would include items such as field experiments and demonstrations, market studies, and end-user financial assistance.

STIMULATING MARKET BETTER THAN CONTROLLING MARKET Those items that had the effect of controlling the market or redirecting it, such as subsidizing prices and market guarantees, tended to have a low ranking. This indicates that companies prefer to have the market conditions left to the natural forces rather than controlled. Controlling a market generally disinterests prospective investors because they, in most cases, are unable to use their principal strengths and assets to a maximum potential. If, however, government incentives tend to stimulate the natural development of the market, then this provides even greater opportunities for prospective investors to take advantage of their particular company strengths and maximize the return on the investment.

LOW RANKING FOR GFE AND MANAGEMENT FEE The major influence that the GFE and management fee incentives offer is in the area of the absolute barriers. This is because they have a significant influence upon the base on which an investment is evaluated and the returns or revenues are measured. The ranking, however, of these incentives is still extremely low regardless of which method of measuring or weighting is used.

The major reason for their overall low ranking stems from the fact that industry views these two particular incentives as having a significant influence upon the company's internal affairs and have associated with them various restrictions or hinderances that are not deemed worthwhile. Few companies find these incentives very desirable when involved with a highly competitive commercial market in which technology is rapidly changing. This does not mean that GFE and management fee routes have no place at all in the American industrial complex. It just means it does not have applicable use in the case of photovoltaics.

PRODUCTION DEMONSTRATIONS BIAS CONDITIONS Production demonstrations have relatively little influence upon inducing companies to enter the photovoltaic venture. Most companies are pursuing their own unique production routes independent of the involvement of the federal government in such activities or areas. Each company is building a production facility based on their own beliefs of what is best, most efficient, and economical for them. Production demonstrations can be thought of as the development aspect of research and development activities.

The real benefit of production demonstrations seems to be in the early attraction of those companies that were interested in doing the work in that particular area in the first place. They probably had reasons for not pursuing it internally, but because of the funds available through production demonstration projects, these companies were able to justify an earlier pursuit of the project.

In addition, these companies probably expected no proprietary position to evolve out of these projects. Their hope is that by participating in the early developmental stages of these production demonstration projects, they will be in a prime position to be knowledgeable and experienced with these new procedures, techniques, and technologies that are brought to light in production demonstrations. The benefit is then derived from actually having done the project rather than from knowing what the results of the project are. They are then positioned to that advantage of their experience when the market does develop.

For this reason, production demonstrations tend to bias that portion of the market and supply area toward the insiders or the ones that participated in the demonstration projects and does not seem to offer significant advantages to those outside of the project. The

fact that a production demonstration project was implemented does have the influence of probably accelerating the time frame in which the prospective company was originally planning to make the necessary investments in the technology and pilot facilities associated with the project. From this perspective, it could be said that production demonstrations accelerate the development of the supply aspect and causes companies to commit to the venture prior to their otherwise planned time frame.

LOAN GUARANTEES HAVE NO EFFECT Loan guarantees appear to rank at the bottom regardless of what scheme is used. This is not because they have significant negative influences upon reducing barriers or risk factors, but they seem to have no positive influence, especially in connection with a prospective investing company. The possible use of loan guarantees may better be applied at the end-user level if for some reason an end-user is limited in purchasing photovoltaic-powered products because of availability of money. By establishing loan guarantees, possibly an end-user could be stimulated into purchasing photovoltaic products.

The agricultural field may be a prime area that would most benefit from loan guarantees. Most farm equipment and facilities are installed with borrowed money. Assuming that cost-effective photovoltaic products could be brought to the agricultural market, then a loan guarantee might assure that the agricultural industry could and would implement the photovoltaic products.

In most other market areas, however, availability of funds is not the expected limitation in the use of photovoltaics. It will also tend to lose its significance in the agricultural field as the individual farmer in the US is replaced by large corporate farming activities. These corporate farming groups will tend to have greater financial assets available to them and will have a less need for loan guarantees.

RECOMMENDED GOVERNMENT INCENTIVES

Based upon the influences that various government incentives have upon the overall spectrum of investment barriers and perceived risks, the ranking or classifying of government incentives into recommended and not recommended use is shown in Table 4.5. In addition, two incentive options have been listed as having possible use under special conditions. The recommended government incentives are:

- Subsidize research and development activities
- Establish supplier tax preferences
- Market studies
- Field experiments and demonstrations
- Establish end-user tax preferences

TABLE 4.5
RECOMMENDATIONS ON GOVERNMENT INCENTIVES

Government Action	Commentary
Recommended	
Subsidize R&D	Most effective cost reduction program
Supplier tax preference	Reduce low financial reward barrier
Market studies	Direct at basic driving forces of markets, expand to detailed international scope, cover institutional issues
Field experiments/demonstrations	Redirect emphases to experimental aspects, direct at future markets on timely basis
End-user financial assistance	Stimulate market demand, begin with large incentive but decrease as prices decline
Possible	
Production demonstrations	Directed at only common materials or items for all suppliers; tends to exclude outsiders, biases market in favor of insiders
Loan guarantees	Appears to have no real influence; may assist new company formation or special temporary company conditions; best applied to users if needed to stimulate market
Not Recommended	
Subsidize prices	Overrules incentive to reduce costs, prolongs inefficiencies, slows technology advancement.
Market guarantee	Keeps prices up; inefficient use of tax dollars, similar influence to price subsidies
GFE	Biases market, does not stimulate market or advance R&D, freezes production technology, reduces implementation
Management fee	Same as GFE

The two possible government incentives that could be implemented under certain conditions are production demonstrations and loan guarantees. Those government incentives that are not recommended for implementation in the photovoltaic venture are:

- Subsidize prices
- Market guarantees
- GFE
- Management fee

In general, recommended government incentives accomplish the following objectives:

- Provide the most effective means to accomplishing step functions in the reduction of operating and manufacturing costs in the production of photovoltaic products (subsidize R&D)

- Provide a basis for reducing the investment required on the part of a company with minimal interference with internal affairs (supplier tax preferences)

- Provide information concerning the characteristics of the markets to be served and demonstrate to both the supplier and the user that photovoltaics can be effective in given markets (market studies, field experiments/demonstrations)

- Provide incentives for the end-user in a financial aspect that causes the increase in market demand without controlling or dominating the normal market relationships and driving forces (end-user financial assistance)

For those incentives that are listed as not recommended for the photovoltaic venture, the primary reasons for not using them are:

- They tend to override the natural market forces and their normal relationship to each other

- They tend to significantly interfere with internal affairs and the controlling of a company's own destiny

- They have a tendency of freezing or retarding the development pace of manufacturing and basic technology

There are those government incentives that under special conditions could offer momentary or localized positive influences upon the industrialization process. Before application of these incentives, however, significant study should be applied to their needs and their effect upon the overall long-range objectives of the industrialization process. If they can be implemented without interfering or distorting developments within a company or overruling normal market conditions, then they could very possibly be applied into specific areas.

APPLICATION SEQUENCE OF INCENTIVES IMPORTANT In the area of the recommended government incentives, it is important to note that the sequence in which incentives are applied can accelerate or hinder the industrialization process. For instance, it is important that technology be developed first, upon which field experiments and later demonstrations can be based. It would be unwise to label a field

experiment as a demonstration when the technology had not been fully resolved. A failure in this case would act as a retardant force upon the market area to which it was exposed, and possibly discourage companies from entering the photovoltaic venture.

It would also be wiser to provide the supplier with tax preferences early in the development stage rather than to the end-user. An overstimulation of the market conditions could cause prices to remain at a higher than otherwise expected level.

The implementation of an end-user tax preference too early may be insufficient to account for the difference in selling price and the price needed to induce the end-user to purchase a photovoltaic-powered product. Thus the tax preference would have little relevance to the mass public. Only the very wealthy would be able to take advantage of the tax preference. Thus it could be concluded by the general public that government was once again favoring those who have great financial resources and discriminating against the lesser wealthy individuals within the population.

End-user tax preferences must be in relationship to the difference between selling price and the price the end-user would normally pay for some other source of energy. If that delta difference is extremely large, this would be an extremely inefficient use of tax funds. Those funds could better be directed at subsidizing the research and development activity and providing a basis for reducing costs on the supplier side.

A well-coordinated program is thus needed before government incentives are to be applied. Timing is important in the overall effect of the government incentives. The fundamental basis for the photovoltaic venture is the technology. Second is the supply of cost-effective products, and third the stimulation and development of the market to consume the output from production facilities.

5. Leading Indicators

5.1 OBJECTIVES

The principal intent is to identify those leading indicators that give constructive and timely feedback concerning the influence of government incentives on the industrialization process. It would be desirable to know, for example, the immediate effect of an incentive on market development and investments in the photovoltaic venture. By monitoring such indicators, it would then be possible to withdraw or at least modify incentives that are either not effective or creating negative influences.

Several indicators could be selected that would provide information concerning the progress of the industrialization process. However, due to the timing of these indicators, they can hardly be considered as leading indicators. Such an indicator would be, for instance, the number of firms participating in the photovoltaic venture. This is an after-the-fact indicator. It does indicate how effective government incentives have been, but does not offer the timely feedback aspect that is desired.

The decision of a company to enter the photovoltaic venture or to significantly expand its present level of participation will in general be kept secret until the last moment. In fact, additional investments by companies that are already in the photovoltaic venture may not be noticeable outside the company for many months after having been made. It will, of course, be obvious at the time of the announcement of a product that a new company has decided to enter the photovoltaic venture. However, the decision to make the investment would have occurred many months in advance of the product announcement.

The conclusion is that it will be very difficult if possible at all to know the exact position of any company, either presently in or contemplating entrance into the photovoltaic venture. Leading indicators in their true sense may then be virtually impossible to identify.

Leading indicators will be only relative in their nature and in the true sense of the word may not be leading at all. Identifiable indicators will undoubtedly have a significant degree of delay built into them because of the secretive environment that will surround a potential investment decision. This is a natural occurrence within the highly competitive industrial environment prevalent within the US. It should not be looked upon negatively or with great disappointment, but instead viewed with the perspective that companies have a legitimate need to protect their proprietary and confidential position until it is determined in the best interest of the company to announce their decisions and intended actions.

5.2 INDICATORS ASSOCIATED WITH QUANTITATIVE ELEMENTS OF THE INVESTMENT ENVIRONMENT

FINANCIAL ANALYSIS ELEMENTS

Each company, when considering the photovoltaic venture, will have calculated a certain ROI and other critical financial measurements. These financial measurements will have entirely different values at each company even though they were based on the same available information concerning market conditions. This is due to the variations in company resources such as the cost of money and expected revenues. A leading indicator showing the direction in which a company is moving would be associated with the change in these financial measurements. If the measurements were becoming more optimistic, then it could be concluded that the government incentives were enhancing the prospects for that company to invest in the photovoltaic venture.

If a set of baseline conditions could be established for a given company or a group of companies, then any change in the baseline conditions could act as a leading indicator. These baseline conditions associated with the financial measurements of the venture may have to be specialized for various company groupings. Several sets of baseline conditions would therefore have to be established, with each set describing a particular grouping of companies as they generally perceive the financial measurements.

The development of this baseline set of conditions implies the establishment of a listing of companies considering the photovoltaic venture and a set of company profiles containing knowledge of what these firms require for the final investment decision to be favorable. Obtaining such information, however, could be extremely difficult and would require a high degree of trust that such information would not become public.

Some companies would not mind sharing this information, especially if the financial measurements indicate that the photovoltaic venture is not a worthwhile opportunity. It is those companies that are close to making a positive decision that would not wish to reveal their perception of the venture. Often companies are willing to share general type information as to their requirements for entering a new venture. Those requirements, however, are generally ideal and are often modified when applied against an actual investment opportunity.

Even though it appears it would be virtually impossible to have a continual dialogue occur with a large cross-section of American companies concerning detailed information about their position on the photovoltaic venture, this should not prevent the establishment of theoretical baseline conditions. Associated with this theoretical set of baseline conditions could also be a sensitivity analysis that would indicate what the effect of a given incentive could possibly produce. If the proper inputs to these theoretical baseline conditions were within reason, then there could be some confidence level associated with the sensitivity analysis performed. The sensitivity analysis could be coupled with a sampling of potential photovoltaic investors to verify or modify the conclusions generated from the analysis.

The basis for such a program is conceivably contained within the JPL-SAMICS program. What is needed is industry inputs to establish the proper baseline conditions. Through periodic sampling, these conditions could be updated and compared to prior results.

"C H A M P I O N" E L E M E N T

One of the principal elements that must be present in the investment environment is the "champion" of the proposed investment. The "champion" will be the principal figure involved in pressing for a positive final decision. This individual will be the most informed as to where the proposed investment stands within the company. It should not be concluded, however, that the "champion" will be aware of the thinking of the final authority group. The "champion" will, however, be in a position to know what information is available, what is still lacking, and the status of the resources available to fulfill the investment criteria.

The identification and continual communication with the "champions" at each prospective company could become a type of leading indicator. Through the communication links associated with these "champions," it would be possible to obtain feedback information that could be used to modify existing government incentives or those incentives that are under consideration. A "testing" of the government incentives under consideration could be obtained through the reaction of the "champions" at each of the identified companies.

This type of leading indicator would not require the government to be informed as to the proprietary position a company holds on a photovoltaic venture consideration, but it could gain insight as to the possible reaction of a given company to a proposed incentive. While this leading indicator would not be quantitative in its output, it could provide significant qualitative inputs.

PRODUCT STANDARDIZATION

Standardization of products is a measure of maturity within an industry. Standardization occurs when an industry has confidence in a market area and believes that certain product types will continue for some reasonable time period.

The appearance of product standards would thus act as an indicator that the photovoltaic industry is maturing and has confidence in the future. This is, however, an after-the-fact indicator and offers no real timely feedback. If the industry establishes standards under pressure from the government, then even product standardization may not be a legitimate indicator. For it to indicate maturity and confidence, it must evolve from within the industry rather than from government enforcement.

TECHNOLOGY AUTOMATION

A significant indicator of the commitment to the photovoltaic venture is the degree to which technologies are automated. Automation implies that a company envisions conditions to have stabilized for at least a certain period. It also indicates that the company has decided which avenues it will pursue in the production of photovoltaic products.

Such an indicator would apply only to those companies already in the photovoltaic venture. Knowledge of the automation may not be readily available, especially prior to its actual implementation. The general announcement of the intent to automate or that automation has occurred within a company will be only at the time when the company feels it is advantageous in the marketplace for it to be known. It is unlikely that the intent to automate will be widely disseminated. Once the investment has been made in automation, however, it may be widely announced to establish a commitment to the product in the eyes of the end-users.

At best, this leading indicator might also be considered an after-the-fact indicator, since automation will be one of the last investments made by a company in the photovoltaic venture. Automation only occurs when stabilized conditions exist. Such stabilized conditions generally do not exist in the early stages of a company's investment in a new venture.

TAX REPORTS

END-USER INFORMATION The overall objective of the industrialization process is to stimulate lower prices and higher volumes of production and consumption. To arrive at an indication of market prices and the volumes involved, the use of the income tax reporting forms could be employed. If, for instance, an end-user stimulation were developed that provided tax credits, rebates, or some appropriate incentive, then it would be possible at the time the annual income tax forms are filed to request certain information of end-users.

There could be a modification to the income tax reporting forms that require the end-user, whether it be an individual or a company, to report the total dollars spent on the photovoltaic systems purchased during the year, the peak watt rating of the system, and any other pertinent information that was desired to indicate the volume and prices prevailing during the past year. From this data a reasonable picture could be formulated as to what was occurring, at least on an annual basis, within the marketplace. It could be determined if volumes were truly increasing and if prices were actually decreasing in any proportionate rate to volume.

SUPPLIER INFORMATION To arrive at some indication of the investments on the part of the photovoltaic suppliers, it is also possible to use the income tax reporting form for companies. Certain tax credits or fast write-off of equipment expenditures and other R&D costs can act as a stimulus to a supplier. The requirement could be added that if the stimulus is to be applied against the earnings of the company, then the company must report certain pertinent information within their tax form. Such information could include estimated number of man-hours devoted to photovoltaics, a listing of specific equipment designated for the photovoltaic venture, capital costs, or any other information that was deemed applicable to indicating the commitment of a company to the photovoltaic venture.

CONFIDENTIALITY REQUIRED The potential negative aspect of these reporting channels is that the supplier may view this as a potential invasion of his proprietary position within the venture and would not want such information to be made public. There must therefore be associated with the collection of this information through the tax forms an environment of confidentiality.

The Internal Revenue Service could accumulate the information contained on the tax forms and provide a summation of the data, such that the photovoltaic industry and the marketplace as a whole could be characterized. It could thus be determined, for instance, if investments on the part of companies not presently in the photovoltaic marketplace are occurring. It would also indicate the

continued commitment of additional funds on the part of companies already within the photovoltaic venture. The overall results, while made public, would not jeopardize any individual company's position.

OFFERS CHECK ON OTHER DATA SOURCES The information obtained concerning the suppliers could legitimately be considered a leading indicator, even though the data is compiled on an annual basis. The data collected from the end-user reports would certainly be a check and balance on data reported by either government market surveys or suppliers as to the actual size of the marketplace. Over a period of time, the data collected from the suppliers could be correlated to the volume of product consumed in the marketplace and average prices. A one-to-one correlation may not exist as inventories can be built at various points between the supplier and the end-user; but even inventory information could possibly be part of the data collection mechanism.

A T T E N D E E S A T P U B L I C M E E T I N G S

The photovoltaic industry and the involvement with the government has one characteristic that may add insights into prospective companies. Associated with the photovoltaic venture is many public meetings in which attendees register their name, position, and company for which they work. This information could become valuable leading indicator material if properly analyzed. The type of information that could be obtained from the attendee lists would include:

- The name of the companies sending representatives
- The frequency of their attendance
- The type of meetings to which companies send representatives
- The number of representatives sent
- The level or job position within a company that each of the attendees represents.

This information is already within the public domain and would require no new forms or data collection mechanisms. It would, however, require a systematic reduction of the data from all public government meetings.

With the significant influence that the US government will play in the industrialization process of the photovoltaic industry, it is unlikely that a company will consider entering the photovoltaic venture without sending a representative to at least certain key meetings to gain information concerning the prospective investment. Representation at such a meeting, however, cannot be construed as a serious indicator that a company is considering the photovoltaic venture. It may very well be a private curiosity that brought the attendee to the meeting.

5.3 INDICATORS ASSOCIATED WITH QUALITATIVE ELEMENTS OF THE INVESTMENT ENVIRONMENT

GOVERNMENT POSITION

It is important within the prospective photovoltaic companies that the position of the government be well known. The clarification of the long-term position of the government is critical to the investment environment. Government involvement, or the lack of it, is not as important as knowing what the specific involvement will be. An unknown government position can be more detrimental than the wrong government position. Industry prefers to work with known elements, even if they are not optimum or desirable.

An indicator of the usefulness of an incentive will be: "Does it clarify the long-term position of the government?" If it indeed does add clarification to the long-term intentions of the government in the photovoltaic venture, then it can be expected to have more positive impact than it might otherwise. It would be advantageous upon the establishment of a new government incentive to obtain industry's reaction as to their interpretation on whether it aids in clarifying the government's long-term position. If a sampling of companies indicated that it did indeed better clarify the long-term position of the government, then it could be considered a positive incentive in that respect. If it offered no additional clarification, then its impact could be considered less than optimal. The leading indicator could thus be the reaction of industry. This is not as quantitative an indicaor as is desired, but it does add insight and feedback as to industry's view and confidence in the government's position.

MARKET IDENTIFICATION

A key indicator of the role of government market studies would be whether the results of such studies were being used to formulate company business plans. The identification of photovoltaic markets and their basic driving forces is critical to any investment plans. Market identification studies on the part of the government should be challenged as to whether they are adding perspective to the identified markets that did not previously exist.

There may be may identified markets in the photovoltaic venture. Another indicator as to the commitment of industry would be how many of these identified markets are being served on a

commercial basis. If a market is served on a commercial basis, this indicates that industry has been able to develop products and manufacturing procedures that are technically and economically viable.

There will, however, be identified markets in which the product may technically be compatible but may not offer the economic viability required for penetration. A key indicator as to the effectivity of the market research studies would be, "Does the report or study resolve problems associated with these nonserved markets? Do they in any fashion offer insights into penetrations of these nonserved markets?" If there are no identifiable government actions directed at resolving issues within the nonserved markets and applications, then this would indicate a lacking in the government programs and policies.

Probably the best indicator as to the effectiveness of government market identification and development studies is whether or not industry actually uses the data provided by such services. It is easy for government reports to be biased to accent a given perspective. In the case of photovoltaics, it is possible that government market studies have been overly optimistic or, where they have been aggressive, have failed to supply the needed supportive information that could justify penetration of markets on a timely basis. It would certainly be expected that early market studies would be more optimistic to encourage the investment in the photovoltaic venture. If, however, the results of such studies are not actually being used to formulate industry plans and strategies, then this would indicate the effectiveness of the program is far below its potential. To verify the use of government market identification material would require a surveying of at least selected companies, both within and out of the photovoltaic venture.

I N D U S T R Y D A T A

An indicator as to the progress on reducing prices and increasing production volume could be extracted from an industry-supported program involved in the collection of such data. Many industries form industry associations. The purpose is to collect industrywide type information as to prices, volumes, major trends, and to forecast future market sizes. The establishment of an industry-supported organization could provide leading indicator data that would show the rate at which prices were declining with accumulated volume and if any step function in prices occurred once new technologies were implemented within the industry. It would also provide a background to measure the effectiveness of a newly implemented government incentive. This would provide an additional check on the data provided through the market studies and reported data through the IRS tax forms if such were adopted.

5.4 CONCLUDING STATEMENTS ON LEADING INDICATORS

High-potential but low-risk market ventures soon evaporate. Since it is easy to make the decision to enter such a market, it consequently attracts many investors early. The potential markets are absorbed by competing companies and the high potential is soon dissipated. High-potential and high-risk market ventures by their nature do not make decisions easy. Consequently, the attraction of a large number of companies into these types of ventures is slow in occurrence. Even with the most aggressive incentive plans, it will still be difficult to attract a large number of companies into such investment conditions. They must arrive at their own independent decision through normal channels before the company's resources can be justified for investment in such ventures.

Decisions in industry for high-risk ventures are based on judgment, courage, and insight in the final analysis, none of which are truly measurable in quantitative values. As a consequence, virtually no analytical perspective can be attached to the leading indicators that have been described above. Most cannot truly classify as leading indicators because of the lack of their timely insights. The quantitative measurement of these indicators is even more difficult to support. Without a reliable and measurable set of leading indicators, the only approach that can be taken in applying government incentives is to direct them toward the fundamentals of the investment environment rather than the special conditions that may exist at selected companies. Through applying fundamentally sound incentives directed at basic barriers, a far greater attraction of the best companies for the industrialization process will occur.

6. Methodology

6.1 INTRODUCTION

This study was driven by the perceived need to know what influence government actions would have on the industrialization of the photovoltaic industry. Identification of such information could be used in formulating government actions to enhance and/or accelerate the industrialization process. Without the understanding of the investment environment within the US industrial complex, it would be easy for government actions to be based on erroneous assumptions and biased viewpoints. Through the establishment of the fundamental characteristics and elements that dominate an investment decision, the proposed government actions can be tailored to provide assets and resources to account for the deficit areas within companies and at the same time not restrict or hinder the use of available strengths and assets already well established.

The foundation and base position that allowed Gnostic Concepts to launch such an investigation was based upon:

- Prior work in the field of photovoltaic market analysis
- Longstanding interaction with the semiconductor industry
- Relationships with executives, management, and other personnel in major US corporations

Many of the major efforts at Gnostic Concepts have been directed at understanding and developing strategic planning for corporations. An extensive background in the collection of data permeates all the major activities at the company.

The company has concentrated on those areas where rapidly changing technical or economic environments create needs for in-depth analysis. Analytic tools such as field surveying, data collection, and computerized analysis support the company's activities.

6.2 STUDY DEVELOPMENT

FIELD SURVEY OF MAJOR US CORPORATIONS

The gathering of the basic information concerning the investment environment was collected through an extensive field interview program directed at photovoltaic suppliers and their parent companies. To add further insights into all aspects of the photovoltaic investment environment, firms having decided not to enter the photovoltaic market were also interviewed. Additional companies considering entry into the photovoltaic field, as well as firms having never considered the photovoltaic venture as an option, were also surveyed. This provided information concerning both the positive and negative acceptance of the photovoltaic venture, and insights into companies that were marginal in their decision at the present time. By marginal is meant that neither an acceptance nor a rejection of the photovoltaic venture had been firmly concluded.

The field survey work included a cross-section of various industries, such as the petrochemical industry, electronic firms, equipment firms, materials companies, and conglomerates. The intent was to determine the common denominators within each industry grouping as well as the diversity that may exist within each grouping.

The interviews covered a broad spectrum of various aspects of each company, including technical and production personnel. The major portion of the interviews, however, was directed at corporate executives involved in the decision-making process for investments. Venture analysis groups and selected staff members whose principal function was to investigate specific areas within new ventures were also included. To obtain the required information, confidentiality had to be guaranteed. Consequently, few company names are referenced within this report. Where company names appear, the data given is based upon published documents or commonly known information within the public domain.

RESEARCH OF GNOSTIC CONCEPTS, INC. MATERIALS

Over the years, many studies have been performed at Gnostic Concepts that involved many of the companies presently within the photovoltaic industry and those considering the venture. These related studies added great insight and a foundation upon which to base further extensive interviews specifically designed for this

study. These related studies also gave insights into the development trends within many high-technology-based industries and markets. Because of this background, the development trends within the photovoltaic industry could better be focused and viewed from a broad number of perspectives. A significant and broadly based comparison background was thus available, to which the major elements of the photovoltaic industrialization process could be compared.

A research of the publicly available written material was also performed. This included annual reports, government-published data, technical journals, pertinent industry journals, news releases, and public speeches given by company executives.

Due to the many market studies performed in the electronic industry, Gnostic Concepts has available an extensive set of interviews with company executives and a spectrum of many other corporate personnel. Through these previous interviews, the necessary relationships had already been established in many cases that allowed the rapid and efficient execution of the needed interview programs for this specific study. These new interviews, along with the previous interview material, formed a significant portion of the basis for the results and conclusions of this study.

INTERACTION WITH JPL PERSONNEL

Before any extensive field work was begun, there were planning sessions with JPL personnel. The objective of these planning sessions was to establish very specific criteria for the content of the report. A detailed outline of procedures was established that indicated companies to be interviewed, the spectrum of data to be collected, the expected content, delivery date of all pertinent documents to JPL, and a thorough review of the intent of the study.

To pace the program and to provide interim milestone checkpoints on the progress of the report, certain interim review meetings and interim reports were issued. Prior to these meetings and reports, there was interaction of JPL and Gnostic Concepts personnel to review the status, content, and quality of the material to be presented.

Once the fundamental information was gathered on the investment environment, activities within the project were then directed at the effect of available government actions upon the various identified elements of the investment environment. The results of the literature search, the field interview program, the available data from related studies and previous interviews, and the interfacing with JPL personnel have all culminated in the issuing of this report.

7. Glossary

Acquisition

The act of one company coming into possession or control of another company, often by the exchange of money, stock, and/or other valued commodities or assets.

Business unit

An operating collection of personnel and assets of a company that is usually held responsible for the financial profit and loss status of the group and the use of those company assets; typically holding a divisional status within the company.

Cash flow

The receipt of payment for goods and services provided; may be widely variant from the time the goods and services were supplied.

"Champion"

Usually one person or a small group of people within a company that are the primary supporters and spokesmen of a proposed investment venture.

Corporate R&D

The centralized research and development activities of a corporation, with resources generally directed at basic research and fundamental problem areas.

Demonstration

The installation and operation of a system in which the technology is well established; the purpose of which is to transfer the confidence to both suppliers and users of the system that the technology is in hand and that economic viability either presently exists or is close at hand.

Experiment

The installation and operation of a system in which the technology is not necessarily solidified or known to be sufficiently developed to guarantee success; the purpose of which is to determine the weak links within the technology and the system and to identify economic barriers that must be resolved to assure financial viability.

FDE

Final decision environment.

GFE

Government-furnished equipment.

IPP

Investment proposal process.

Joint venture

The bringing together of selected assets from two or more established companies to form another company jointly owned by all participating companies; ownership of the newly formed company is in proportion to the agreed-upon value of the assets being supplied by each company at the time of formation of the new company.

JPL

Jet Propulsion Laboratory.

LSA

Low-cost solar array.

Management fee

That money provided by a government to a company responsible for the management and orderly operation of a government-furnished facility.

Market

The area of economic activity in which buyers and sellers come together and the forces of supply and demand affect the exchange of goods and services for financial reward.

"Marriage"

Any loose-knit relationship between two companies, usually associated with some form of long-term contractual agreement on the supply and purchase of selected products and/or services; an aligning of resources that provides a net benefit to both parties involved but does not involve a joint venture or any other creation of a separate entity.

Payback period

A measure of the length of time that it requires the expected earnings from a proposed venture to pay back the initial investment outlay.

PRDA

Program Research and Development Announcement.

Present value

The discounted value of some future asset or receivable.

Process

A series of actions or operations conducive to an end result; in the context of this report it refers to those individual identifiable steps within the manufacturing operation of photovoltaic products that change raw material and consumable items in form, substance, or structure into end products performing the photovoltaic function.

P/V

Photovoltaic.

ROA

Return on assets; see ROI. It is similar in nature but the investment does not include borrowed assets.

ROI

Return on investment; several forms are used but it is based upon the percentage ratio of yearly earnings minus the depreciation divided by the lifetime of the initial investment; the investment includes all assets borrowed as well as those supplied by the company.

Semiconductor-based firm or company

A company that derives its income primarily from the sale of semiconductor components in the merchant market; it may have the status of being a division of a larger corporation, but in such a status it is allowed to operate on an autonomous basis such that the semiconductor division appears as an independent company.

Sensitivity analysis

The varying of the value placed on certain assumed quantities to determine the corresponding effect on the end result of a financial calculation; the intent is to determine those parameters or assumed quantities that have the greatest effect upon the end results.

Subsidize

The supplying of financial support in some fashion by a government to a private person or company to assist an enterprise deemed advantageous to the public.

Systems company

A company devoted principally to the supply, installation, and/or servicing of complete functional systems; they may manufacture certain components for use in the systems, but it is not their prime area of activity; emphasis is on the systems aspects and their intended function.

Tax credits

An allowed reduction through a credit of the actual tax liability of a given company.

Technology

The collection of subtechnologies, processes, and methods of manufacturing that result in the means employed to produce products.

TEG

Thermoelectric generator.

Vertical integration

The expansion of a company into new product areas that require the assimilation of several components to produce an end product that has a higher added value than the sum of the individual components; the end-product performs some function that was otherwise not possible on the basis of the individual components in a stand-alone fashion.